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B60R 22/46

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B7B BVRG

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GB 2304540 A

(58) Field of Search
UK CL (Edition R) **B7B BVRG BVRP BVRR**
INT CL^7 **B60R 22/34 22/46**
Online: WPI, EPODOC, JAPIO

(54) Abstract Title
Seat belt retractor

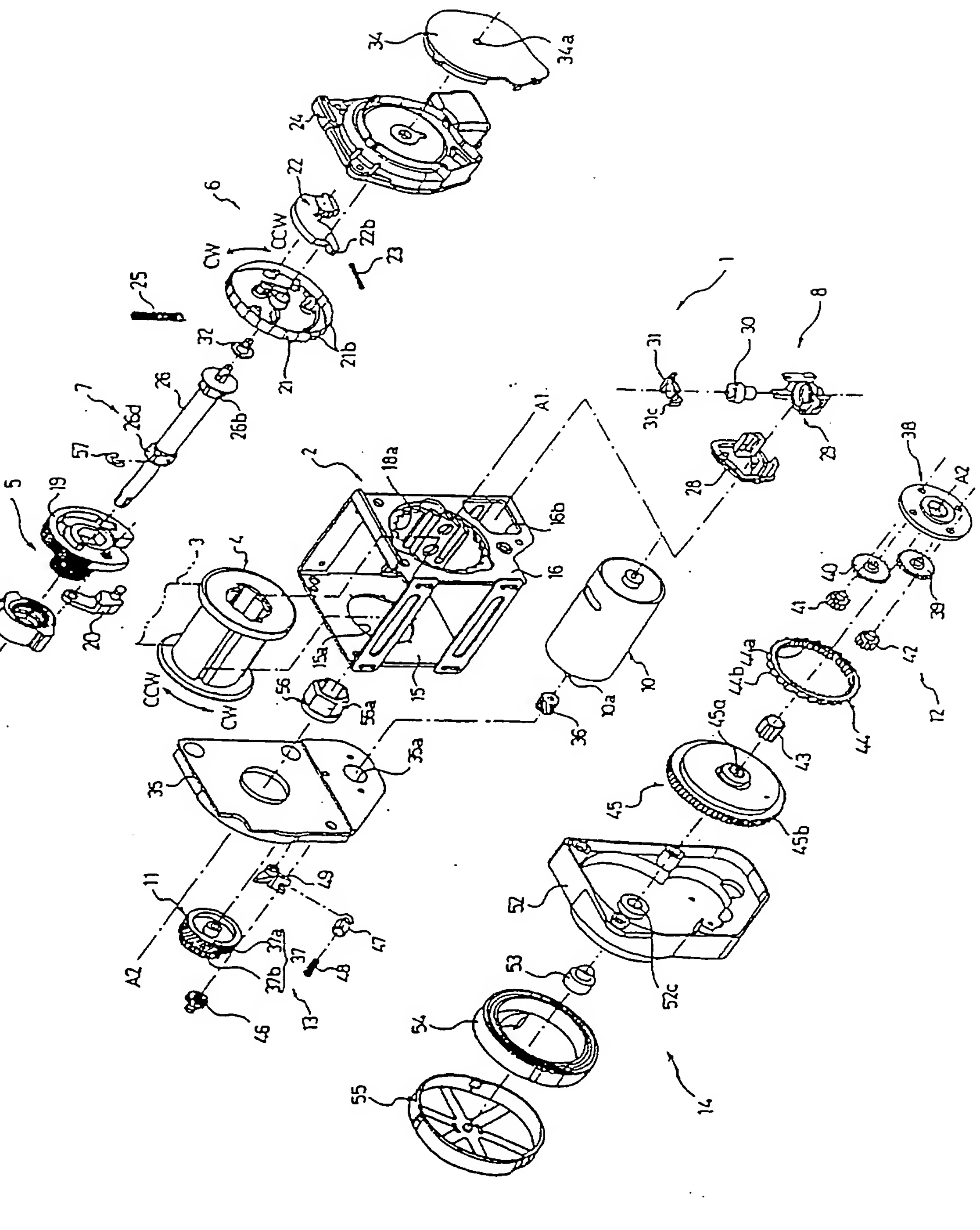
(57) A seat belt retractor has a reel, a locking mechanism and a belt tension control mechanism which includes a motor for generating a rotational torque and a power transmission path having an OFF-state in which a rotational torque is not transmitted between the motor and the reel and an ON-state in which a rotational torque is transmitted. A power transmission path switching mechanism for selectively switching the power transmission path between the ON and OFF states is also provided.

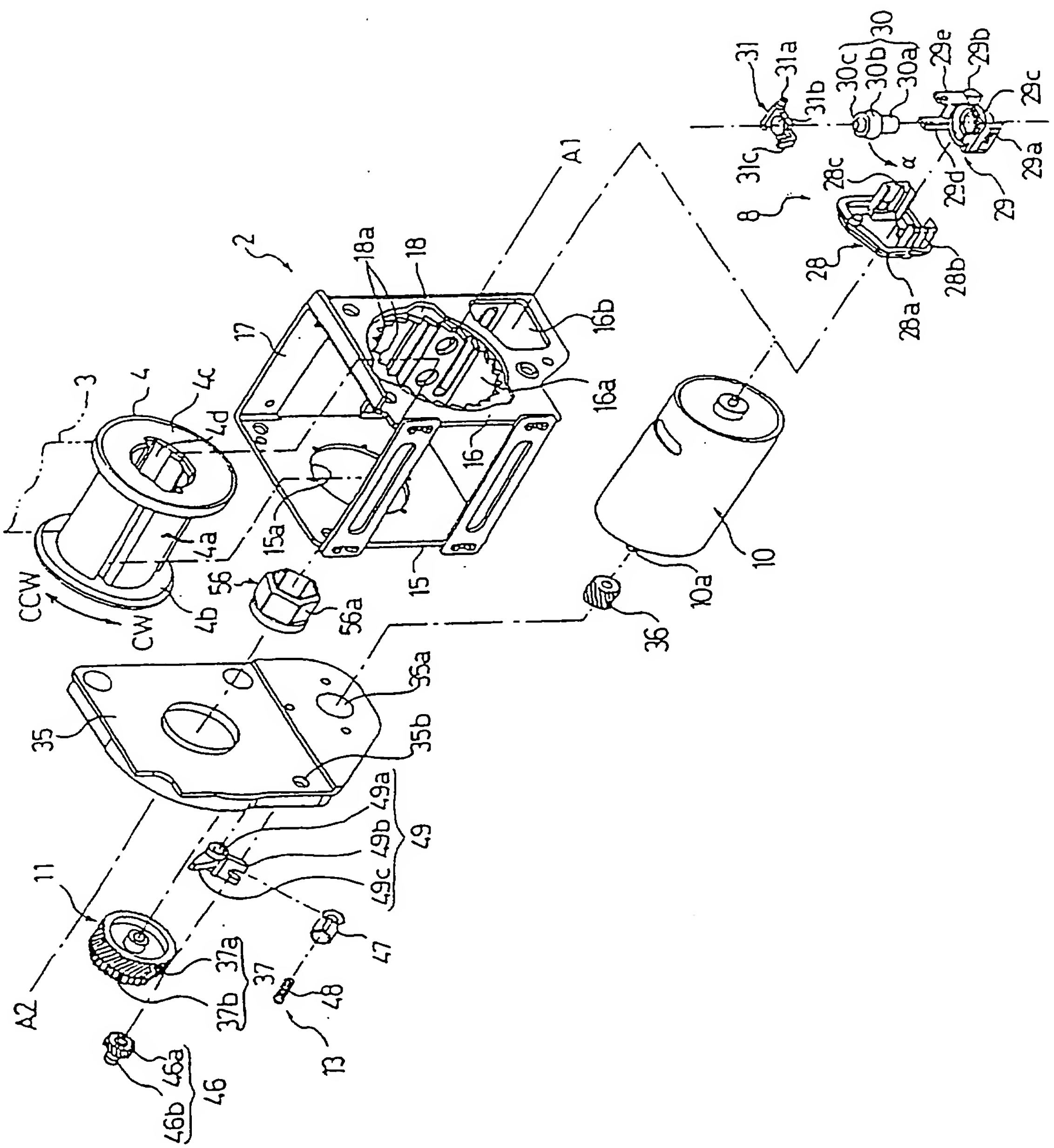
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print incorporates corrections made under Section 117(1) of the Patents Act 1977.

GB 2 354 742 A

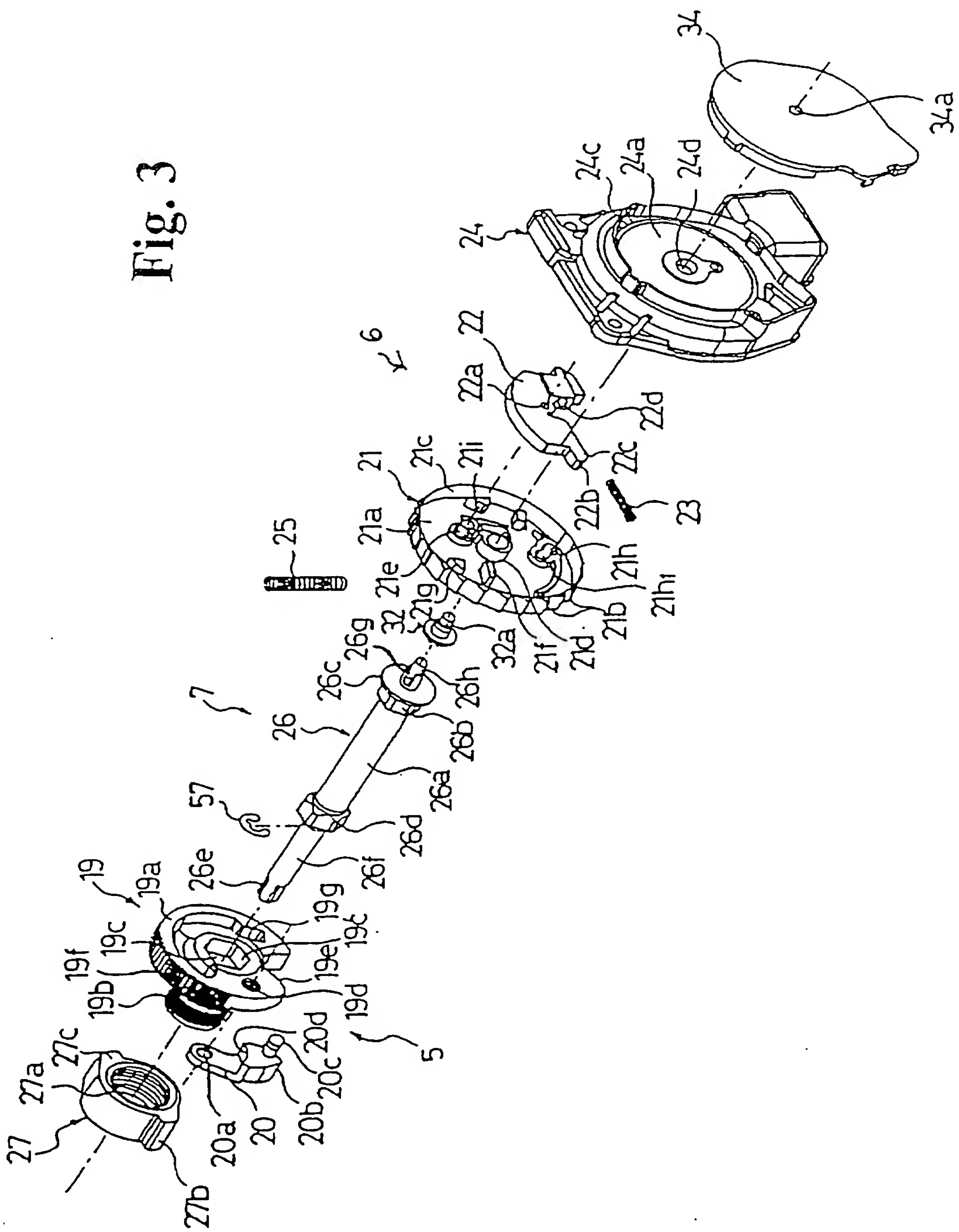
Fig. 1


A1
A2
CW
CCW
1
2
3
4
5
6
7
8
10
10a
11
12
13
14
15
15a
16
16b
18a
19
20
21
21b
22
22b
23
24
25
26
26b
26d
27
28
29
30
31
31c
32
34
34a
35
35a
36
37
37a
37b
38
39
40
41
42
43
44
44a
44b
45
45a
45b
46
47
48
49
52
52c
53
54
55
56
56a
57



2
3
4
4a
4b
4c
4d
CCW
CW
15
15a
16
16a
16b
17
18
18a
A1
A2
8
28
28a
28b
28c
29
29a
29b
29c
29d
29e
30
30a
30b
30c
31
31a
31b
31c
α
10
10a
36
35
35a
35b
56
56a
11
37
37a
37b
46
46a
46b
47
48
49
49a
49b
49c
13

Fig. 2


34
34a
24c
24a
24d
24
22
22a
22d
22c
22b
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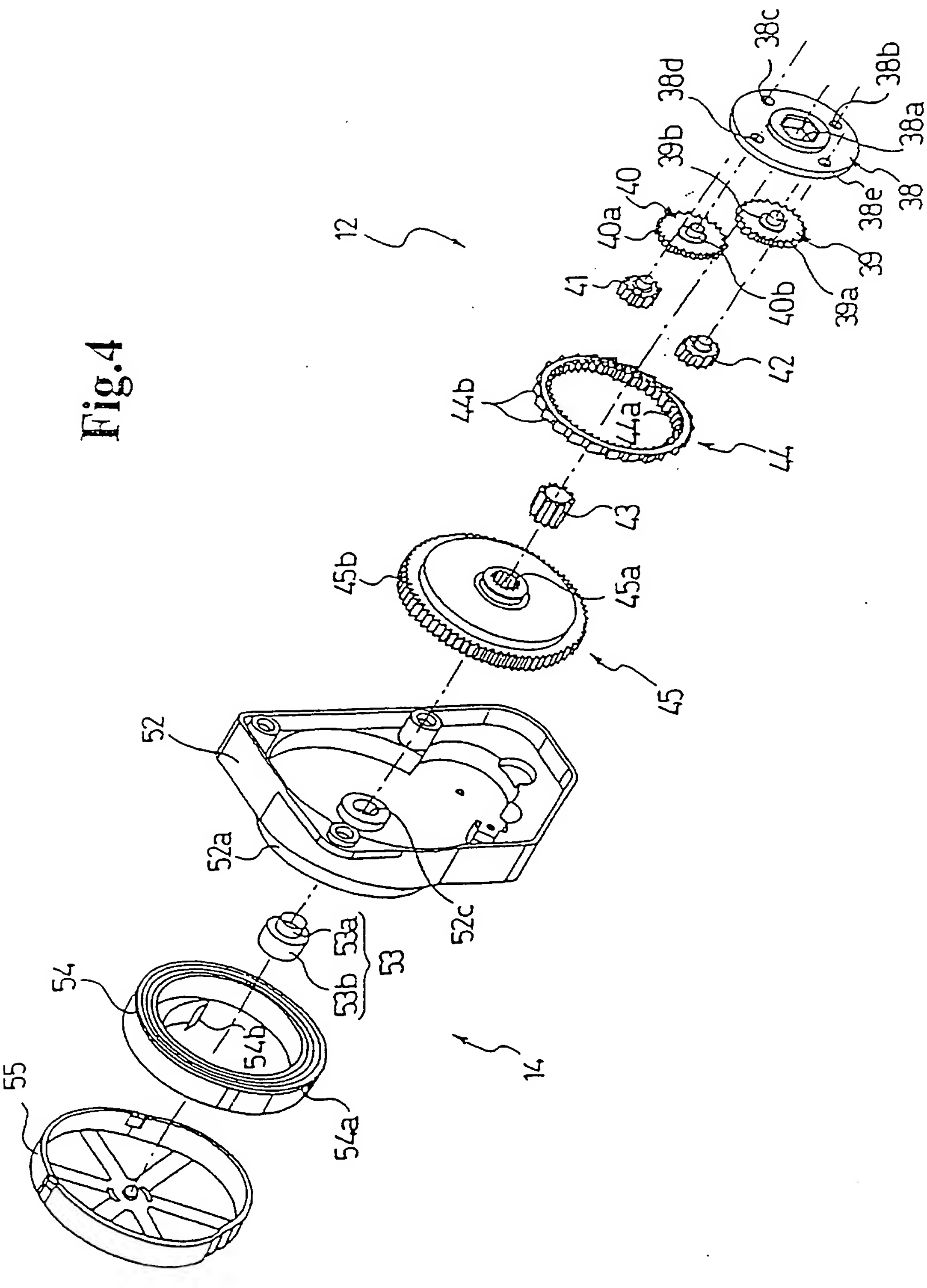
6
21
21c
21i
21a
21e
21g
21h
21h1
21b
21d
21f
25
32
32a
26g
26c
26h
26b
26
7
26a
57
26d
26e
26f
19
19a
19g
19c
19f
19e
19d
19b
20d
20c
20b
20
20a
5
27
27a
27c
27b

Fig. 3

Fig.4


12
38
38a
38b
38c
38d
38e
39
39a
39b
40
40a
40b
41
42
43
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44a
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45a
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52a
52c
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53b
54
54a
54b
55
14

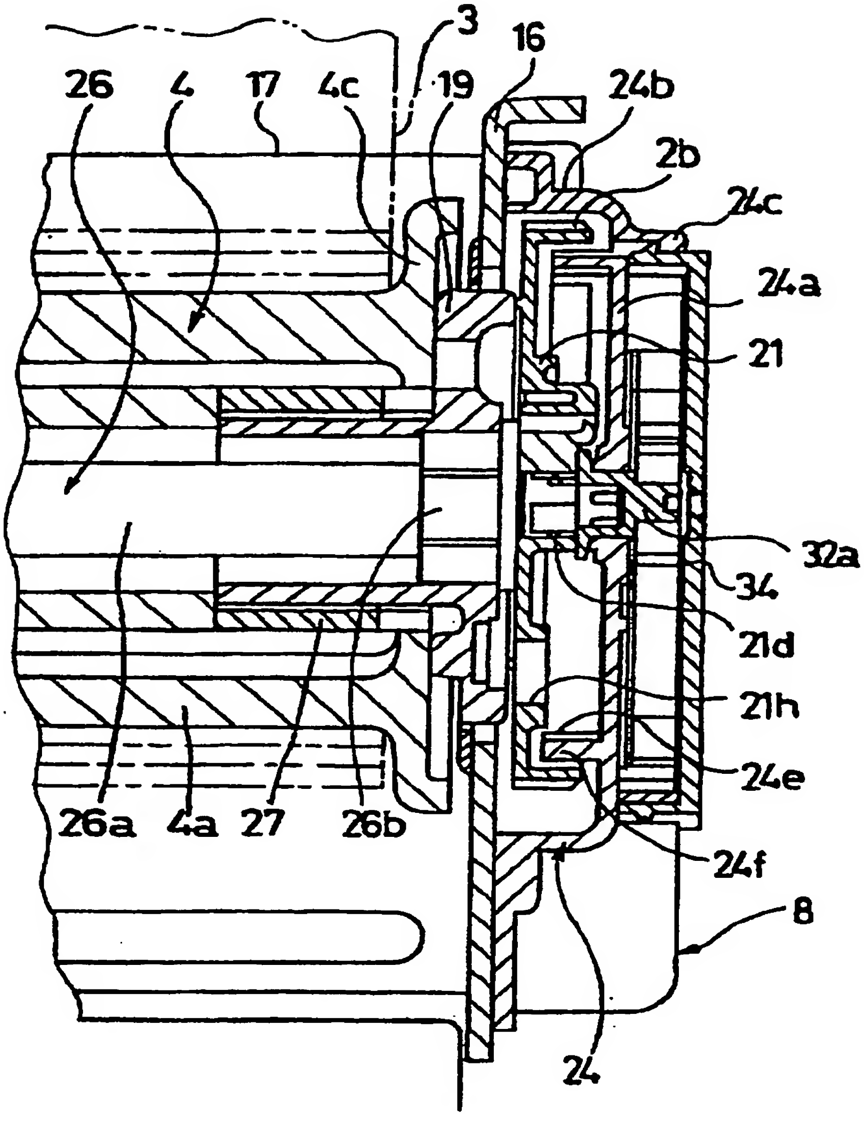

3
16
26
4
17
4c
19
24b
2b
24c
24a
21
32a
34
21d
21h
24e
24f
8
24
26a
4a
27
26b

FIG. 5

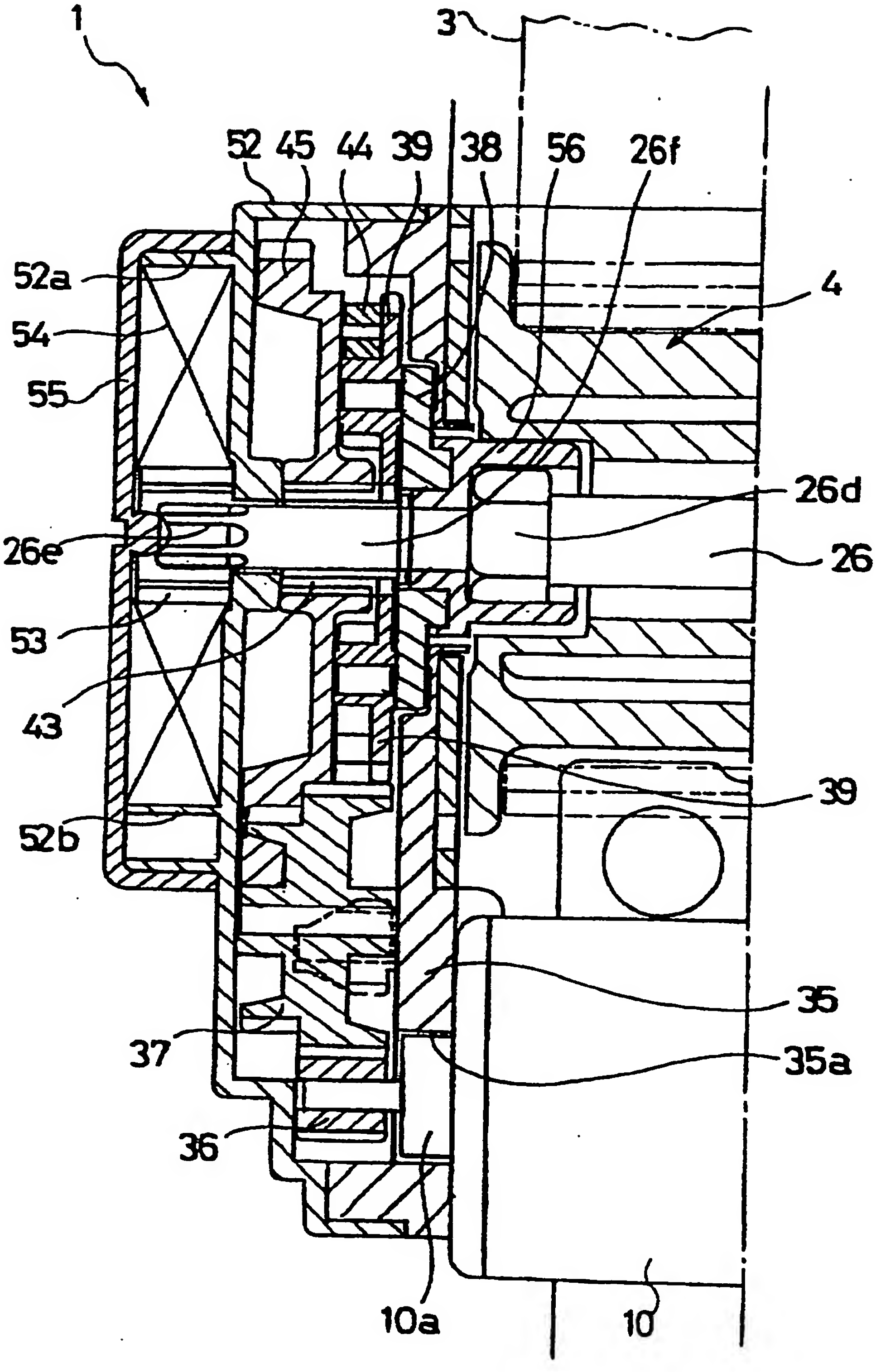

1
3
52
45
44
39
38
56
26f
52a
54
55
4
26d
26e
26
53
43
39
52b
35
37
35a
36
10a
10

FIG. 6

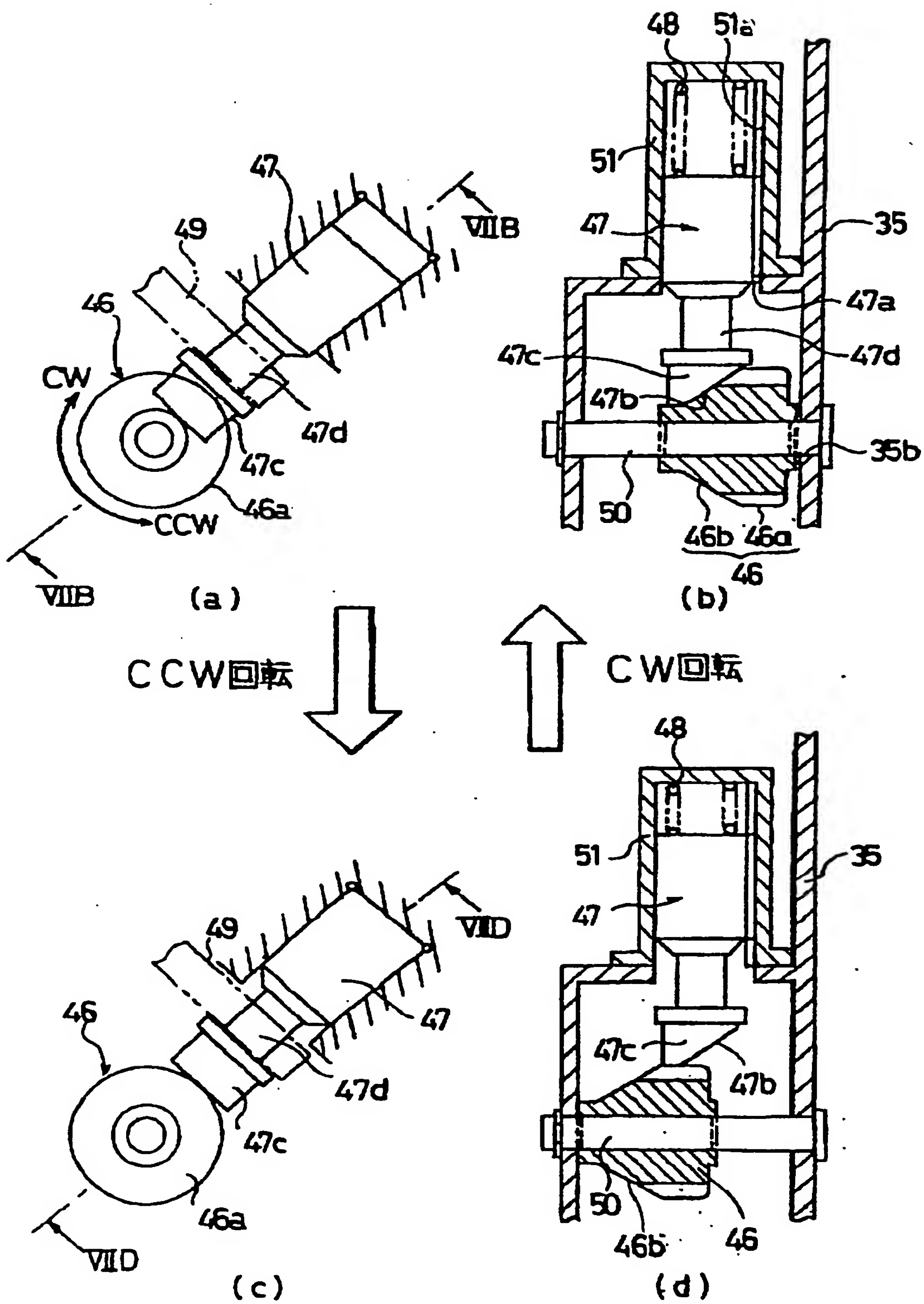
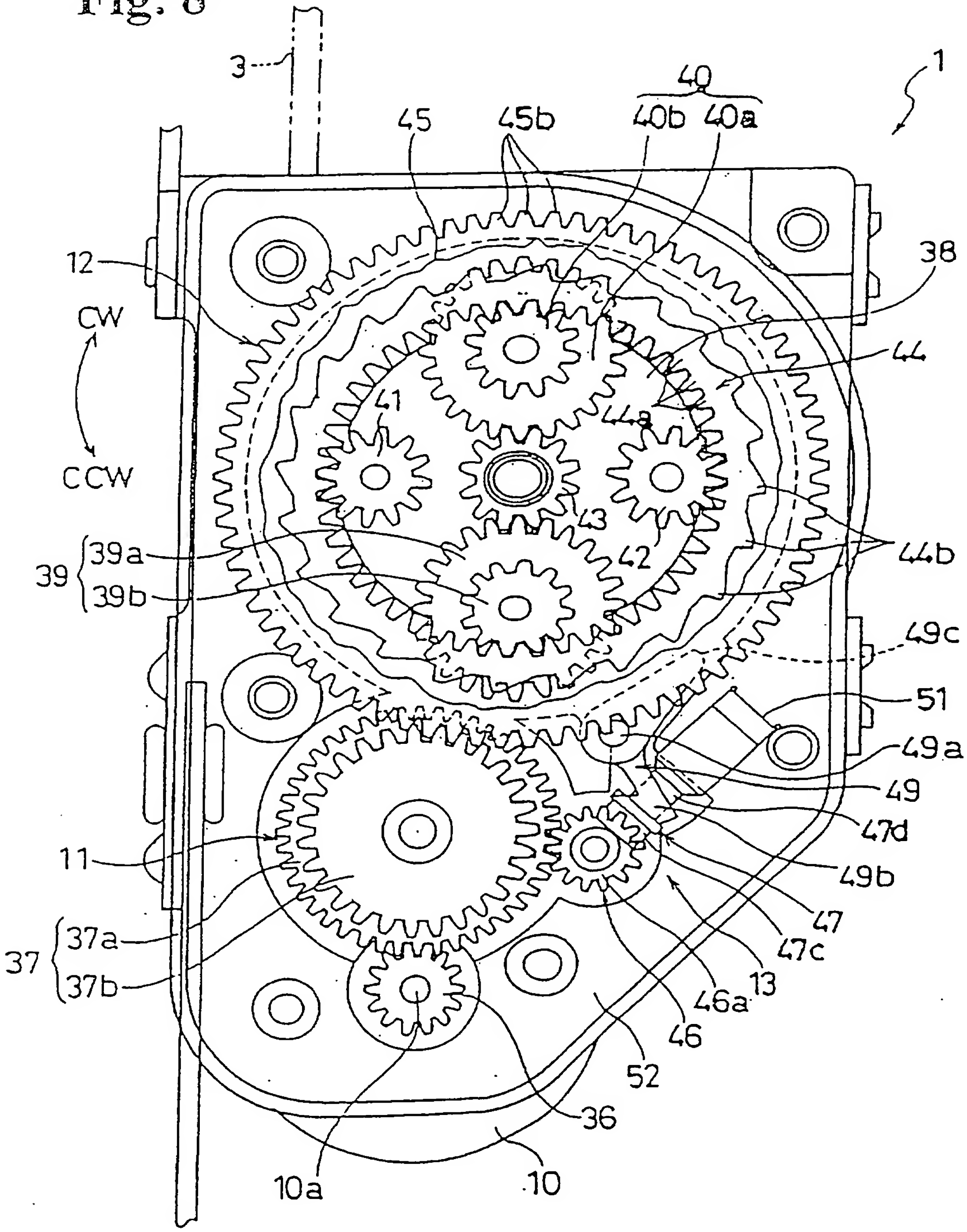

48
51a
51
47
35
47a
47d
47c
47b
35b
50
46b
46a
46
(b)
47
VIIB
49
46
CW
47d
47c
46a
CCW
VIIB
(a)
CCW回転
CW回転
48
51
35
47
VIID
49
47
46
47d
47c
47b
47c
46a
VIID
(c)
50
46b
46
(d)

FIG. 7

8/55

Fig. 8



3
40
40b 40a
45 45b
1
12
38
CW
CCW
44
41
44a
43
42
39 39a
39b
44b
49c
51
49a
49
11
47d
49b
47
37 37a
37b
47c
13
46a
46
52
36
10a
10

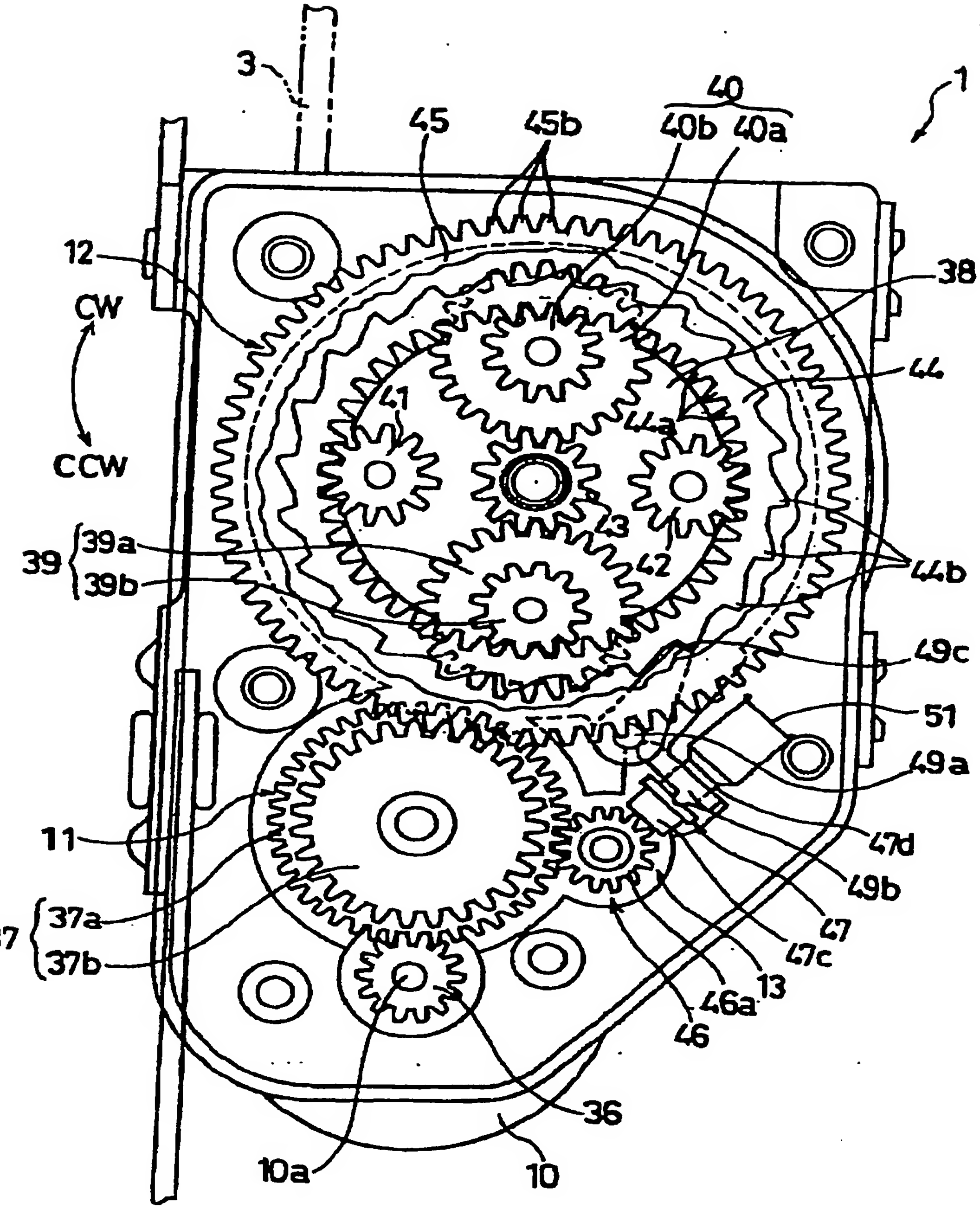
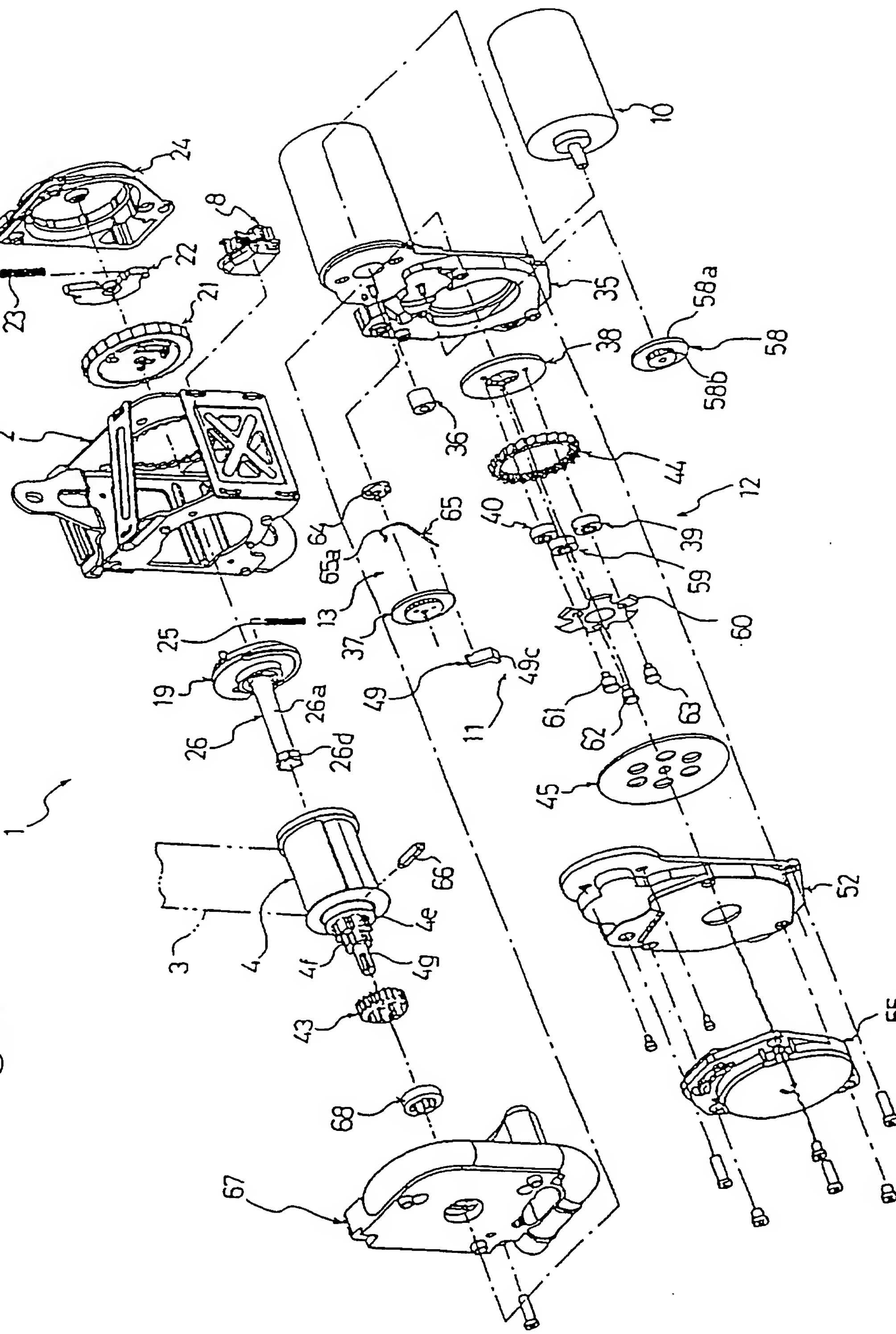

3
1
40
40b 40a
45
45b
12
38
CW
44
44a
41
CCW
43
42
39
39a
39b
44b
49c
51
49a
11
47d
49b
37
37a
37b
47
47c
13
46a
46
36
10a
10

FIG. 9


1
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3
4
4e
4f
4g
8
10
11
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13
19
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22
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24
25
26
26a
26d
35
36
37
38
39
40
43
44
45
49
49c
52
55
58
58a
58b
59
60
61
62
63
64
65
65a
66
67
68

Fig. 10

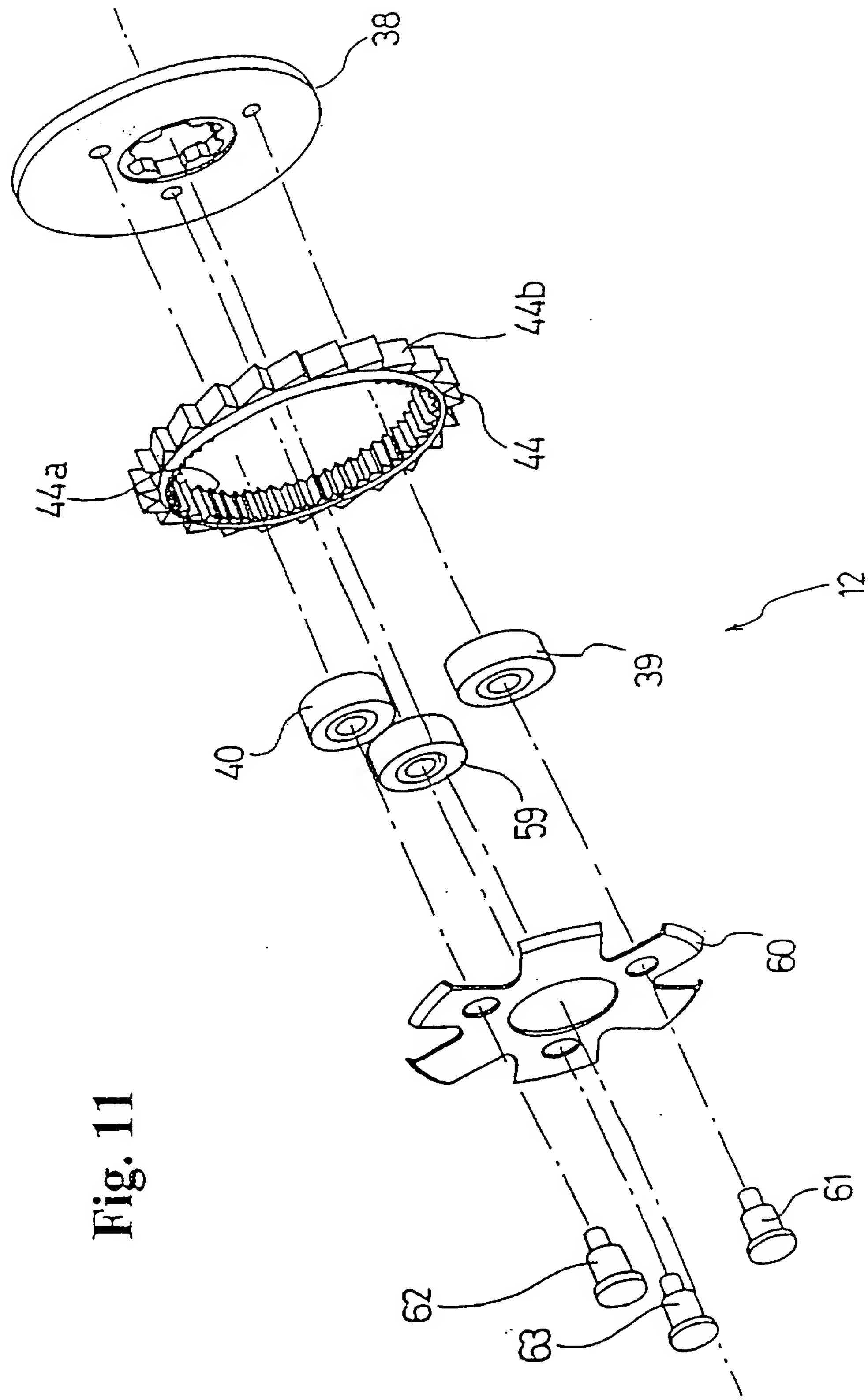


Fig. 11

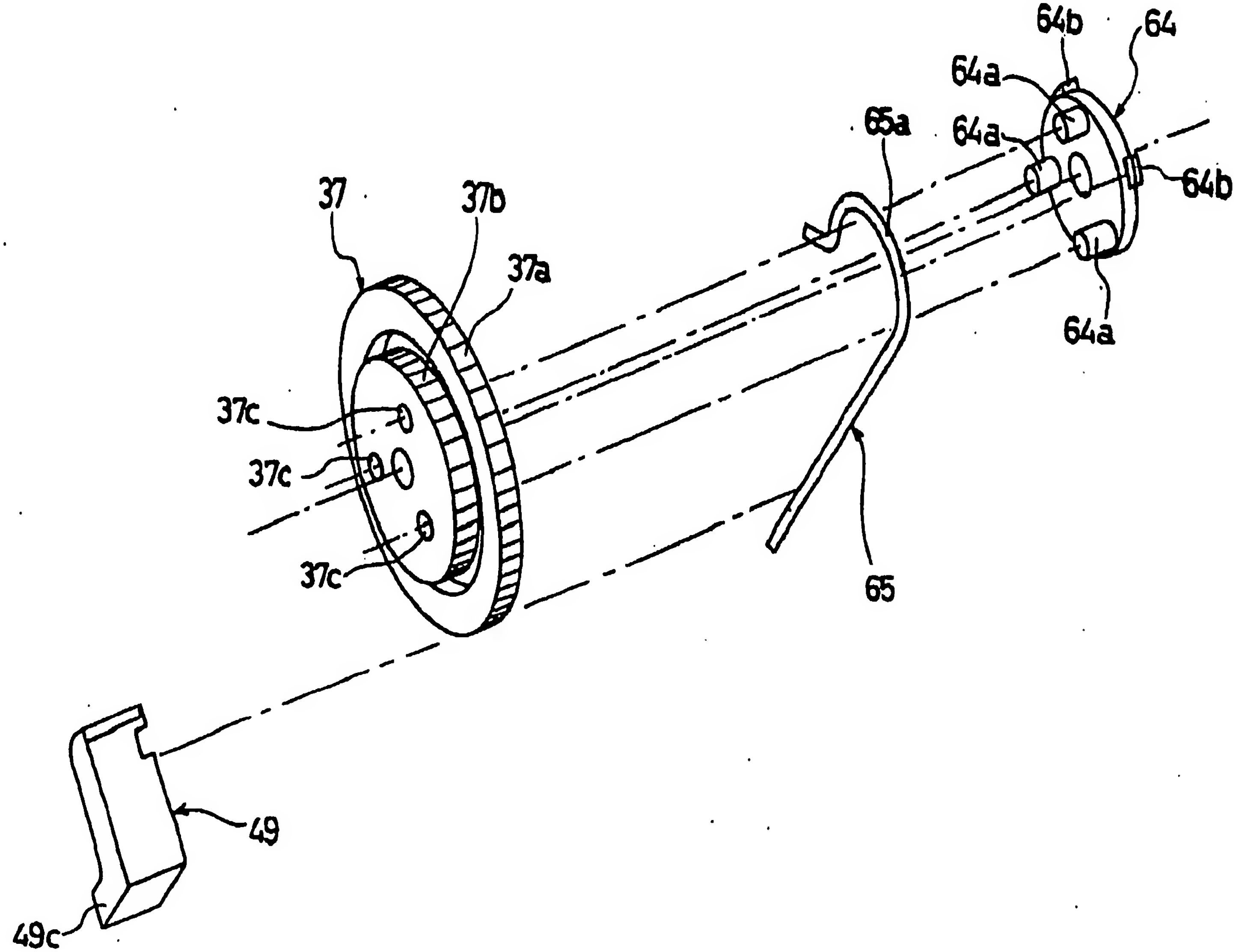


FIG. 12

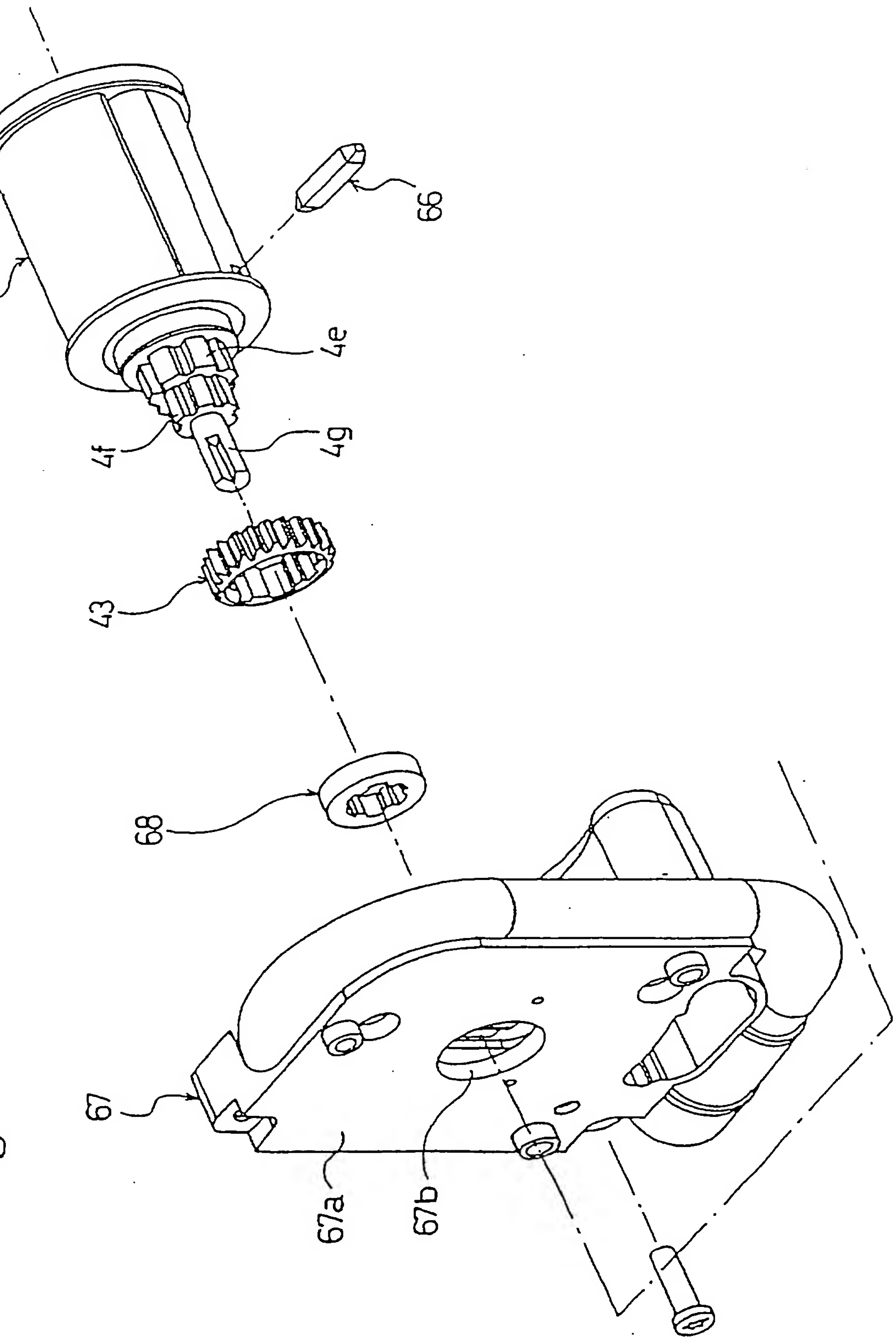


Fig. 13

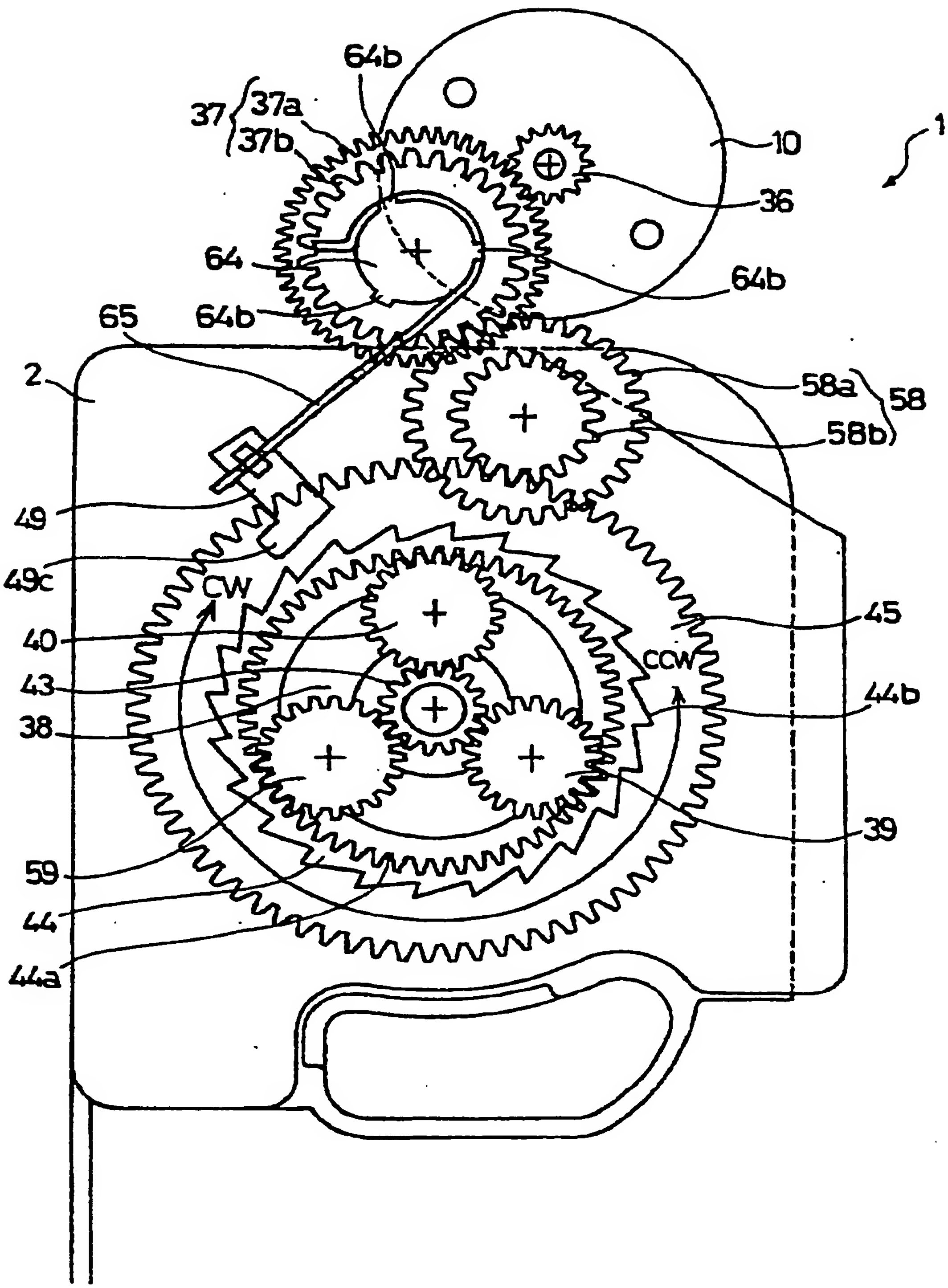

64b
37
37a
37b
10
1
36
64
64b
65
64b
2
58a
58
58b
49
49c
CW
40
45
CCW
43
44b
38
39
59
44
44a

FIG. 14

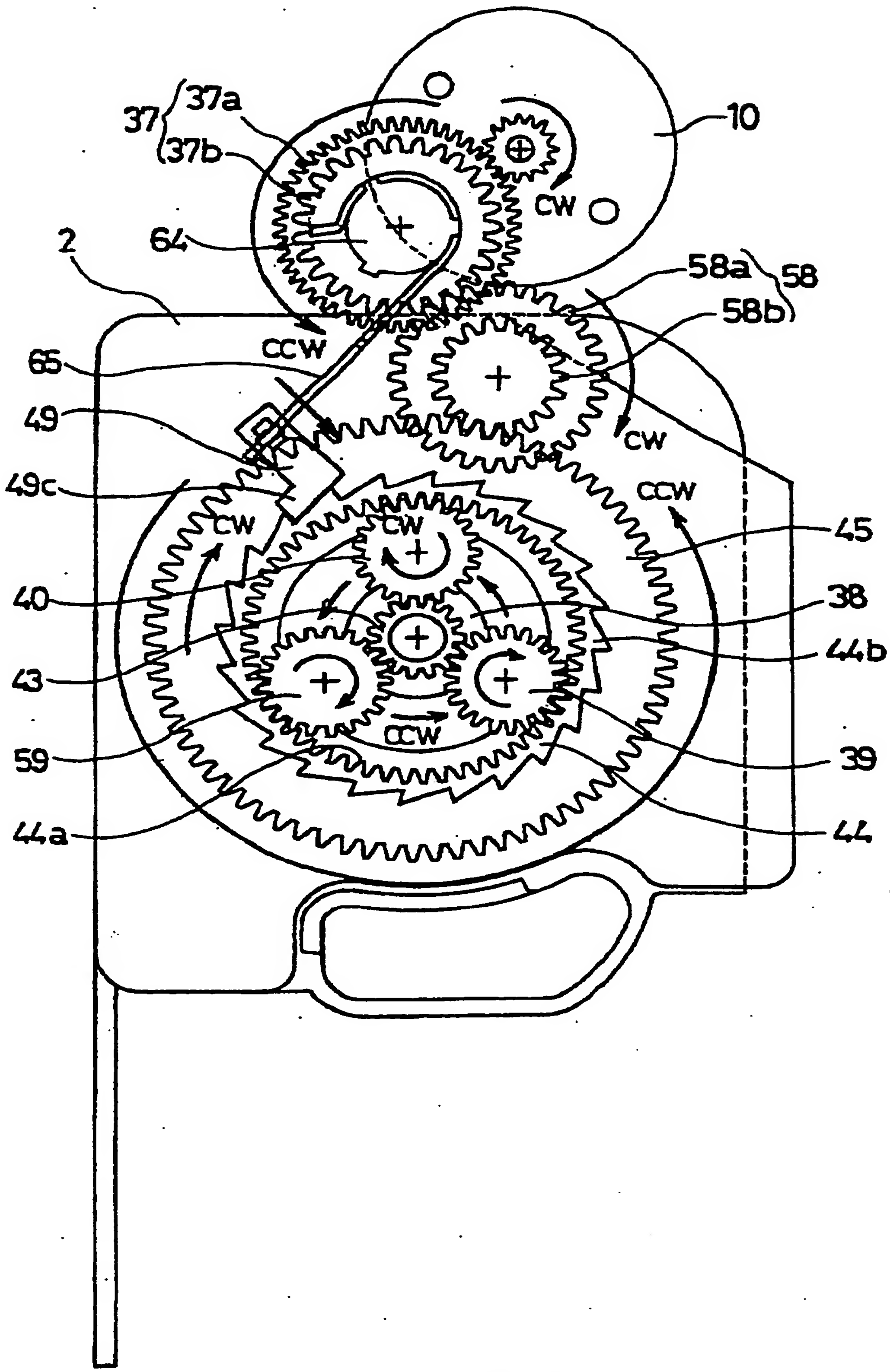

37
37a
37b
10
CW
2
64
58a
58
58b
CCW
65
49
CW
49c
CCW
CW
45
CW
40
38
43
44b
59
CCW
39
44a
44

FIG. 15

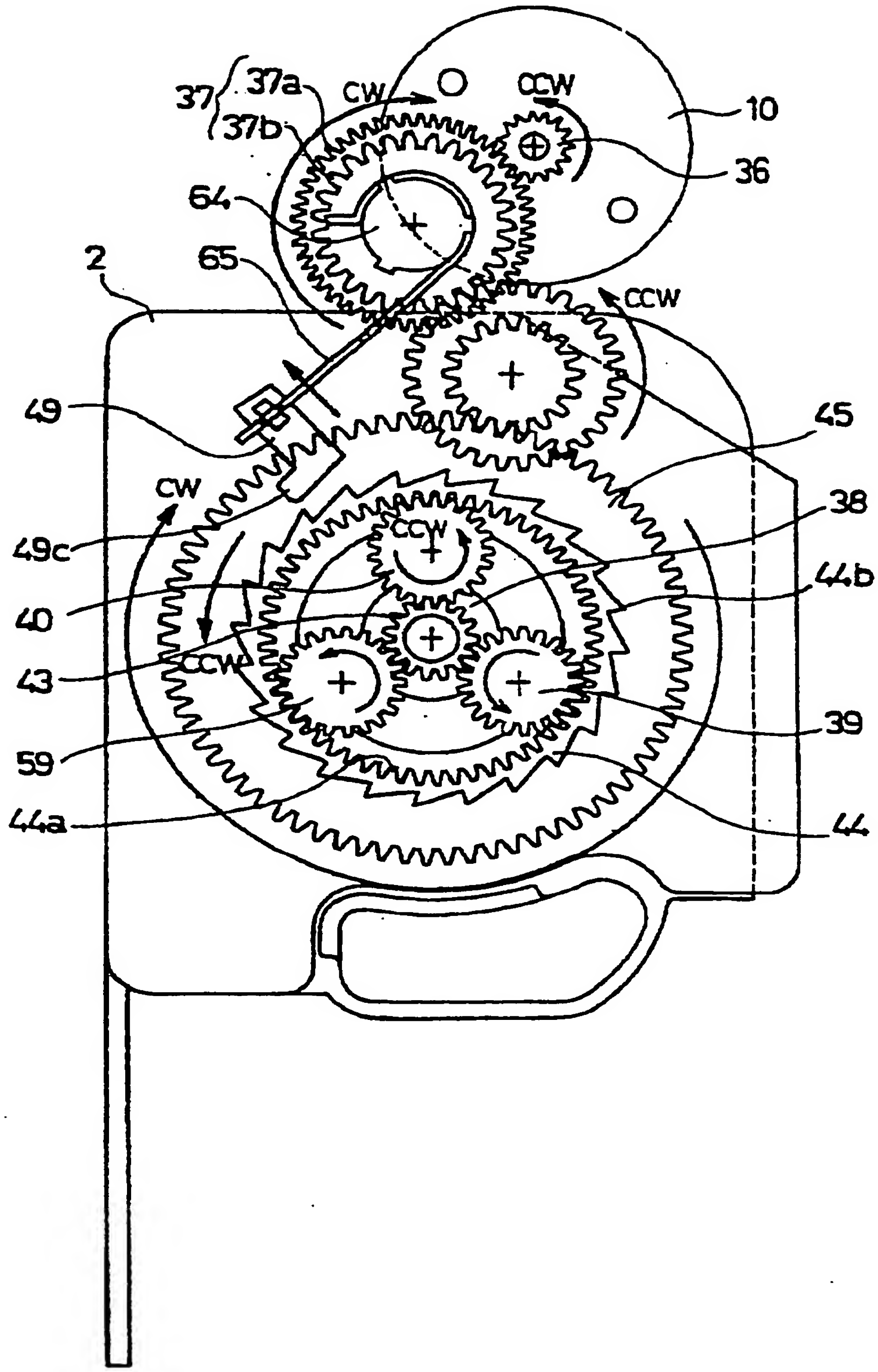
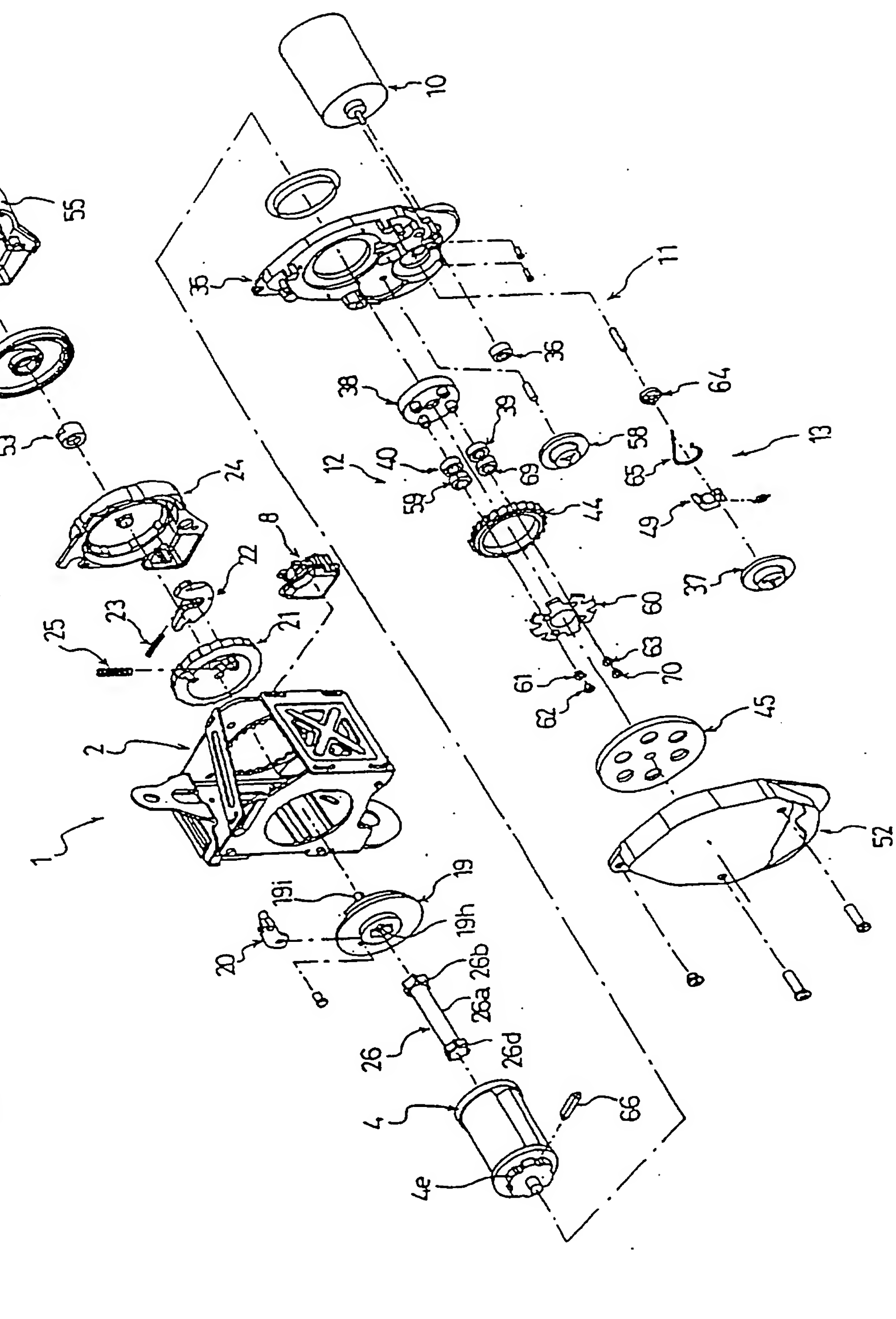

37
37a
37b
CW
CCW
10
36
64
2
65
CCW
49
45
CW
38
49c
CCW
44b
40
43
CCW
39
59
44a
44

FIG. 16


1
2
4
4e
8
10
11
12
13
19
19h
19i
20
21
22
23
24
25
26
26a
26b
26d
35
36
37
38
39
40
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54
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58
59
60
61
62
63
64
65
66
69
70

Fig. 17

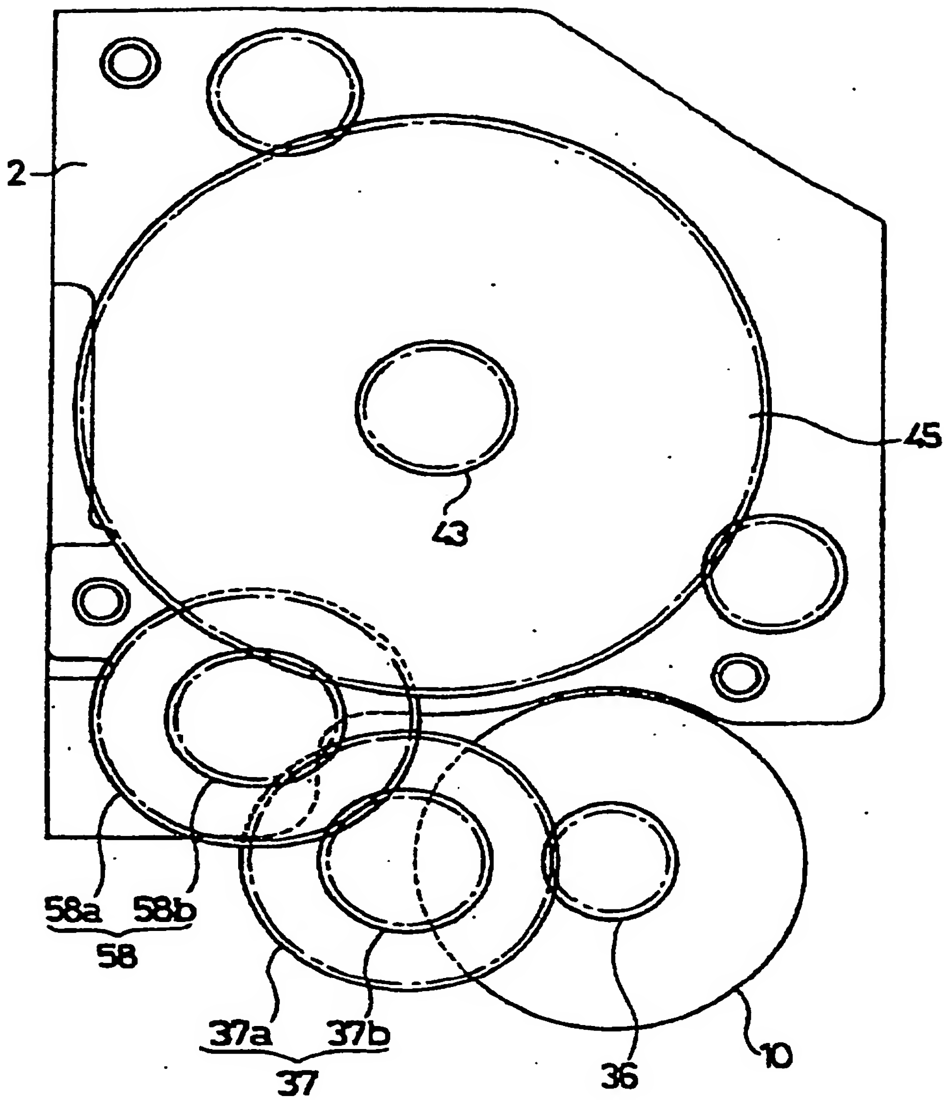
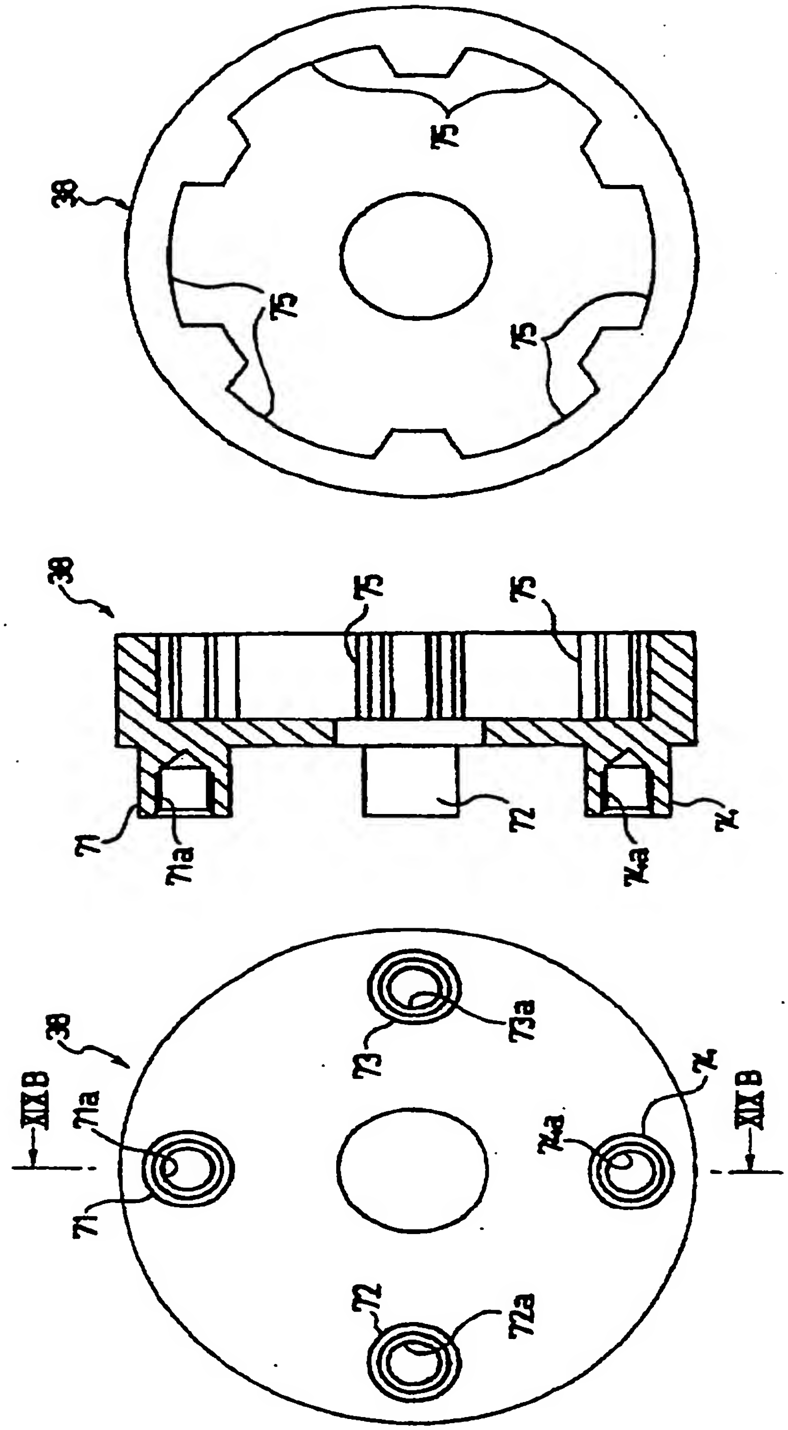


FIG. 18


38
75
75
75
38
75
75
71
71a
72
74
74a
38
XIX B
XIX B
71a
71
73
73a
74
74a
72
72a

(c)

(b)

(a)

FIG. 19

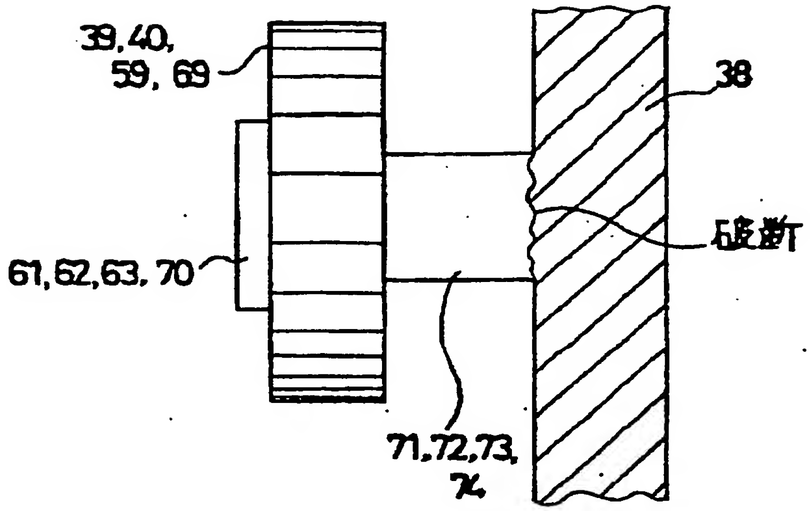


FIG. 20

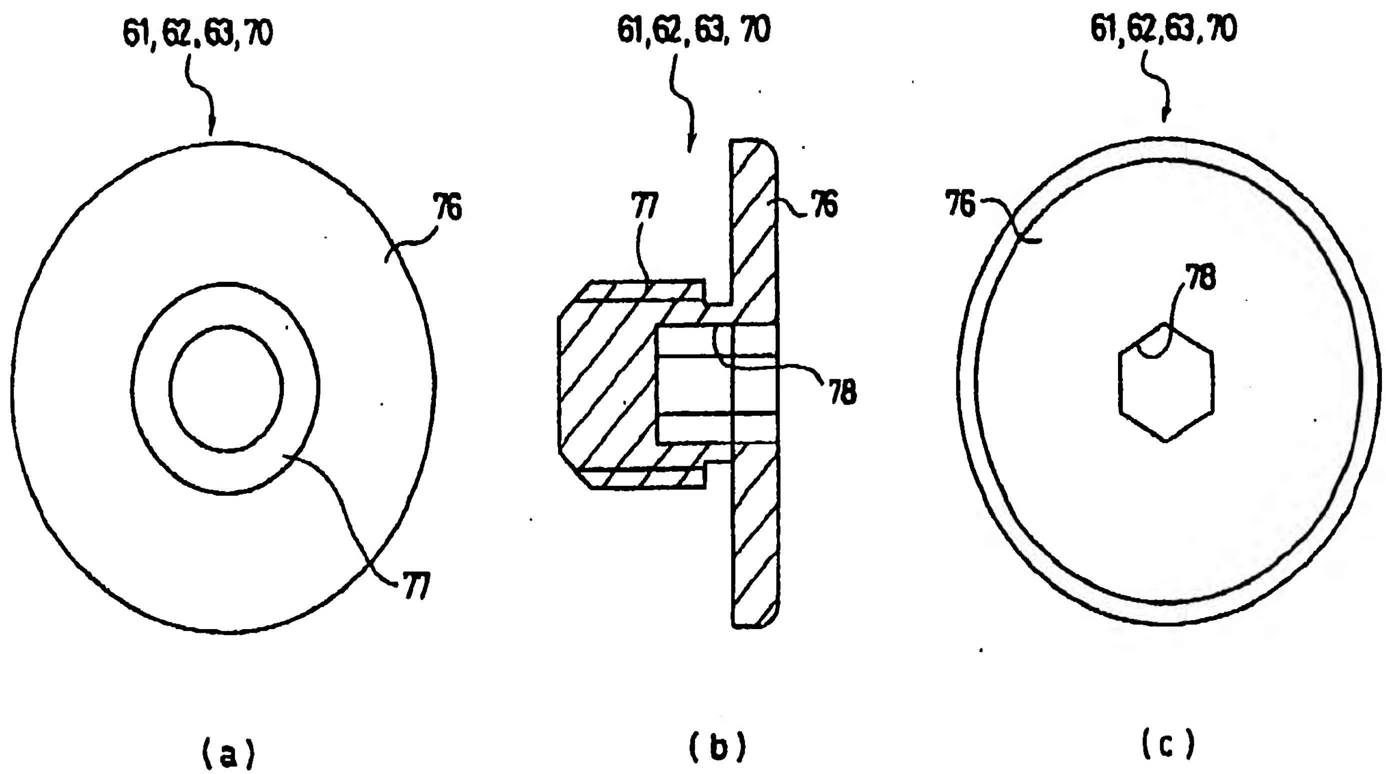
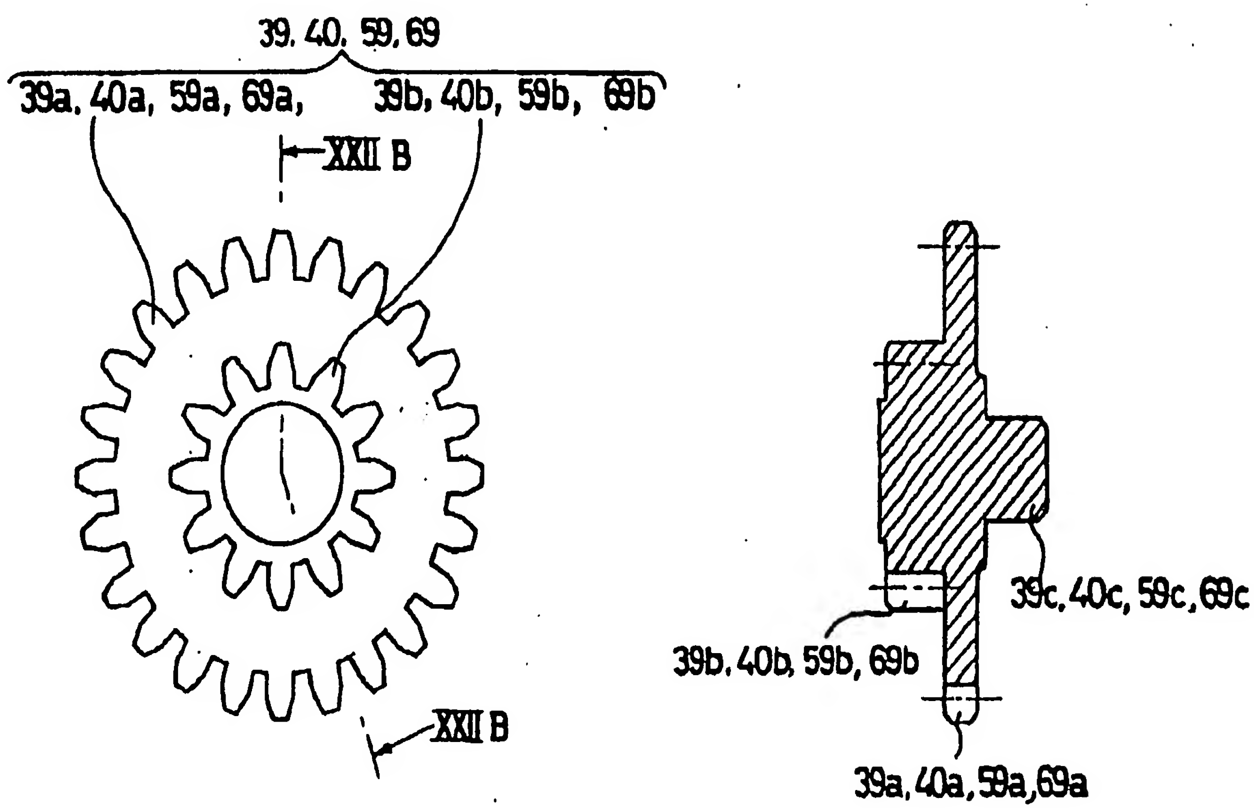


FIG. 21


39. 40. 59. 69
39a. 40a, 59a, 69a,
39b, 40b, 59b, 69b
XXII B
XXII B
39c, 40c, 59c, 69c
39b. 40b. 59b, 69b
39a, 40a, 59a, 69a

(a)

FIG. 22

(b)

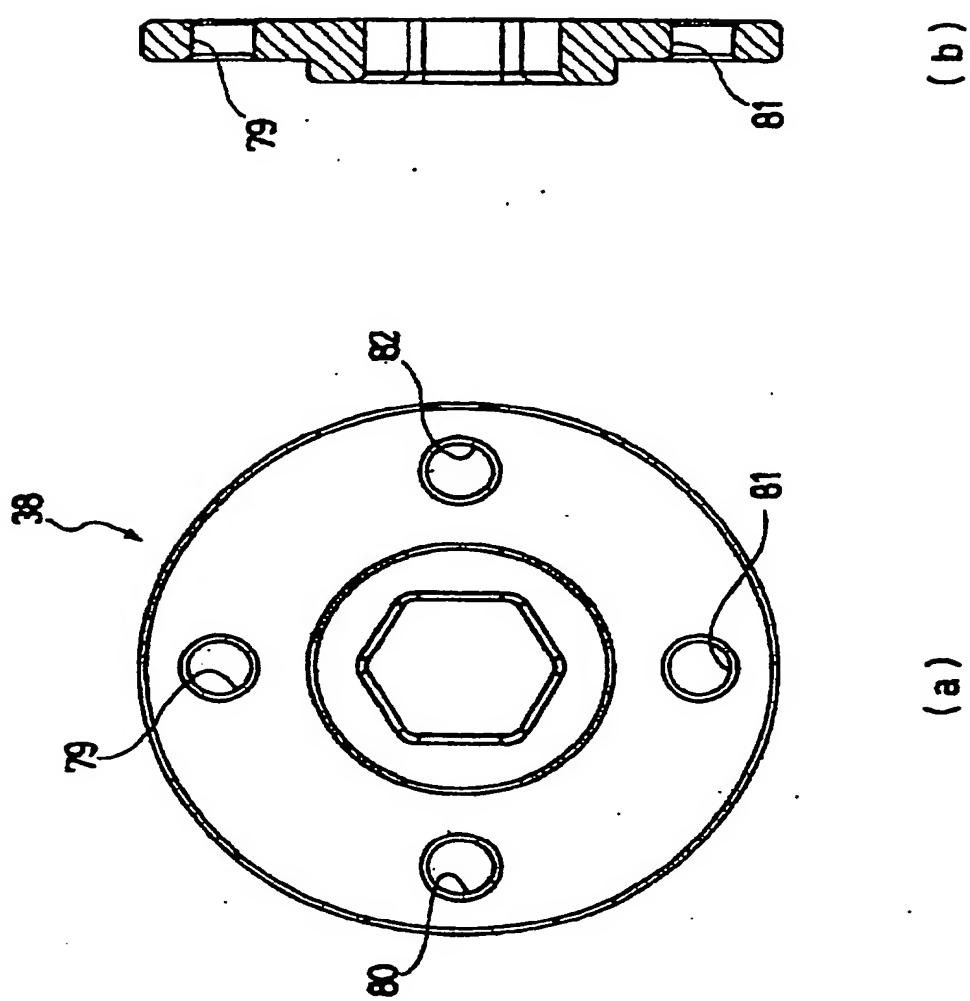


FIG. 23

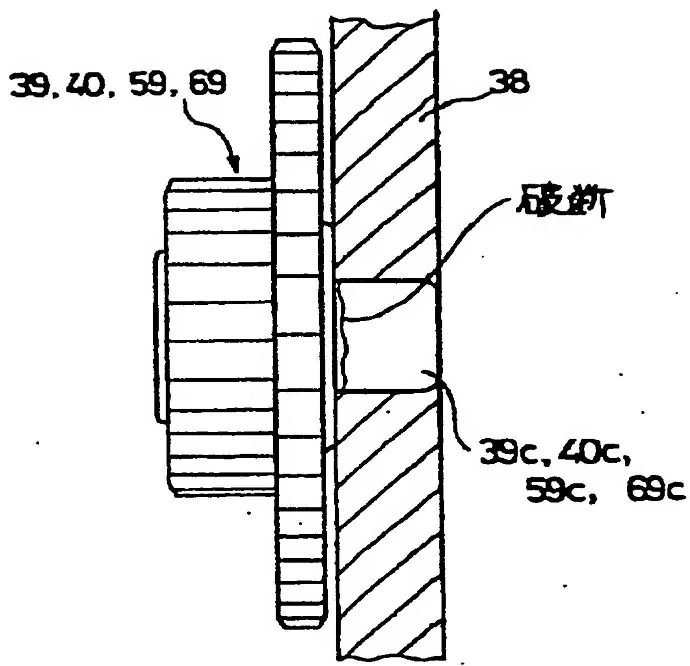

39.40. 59, 69
38
破断
39c, 40c,
59c, 69c

FIG. 24

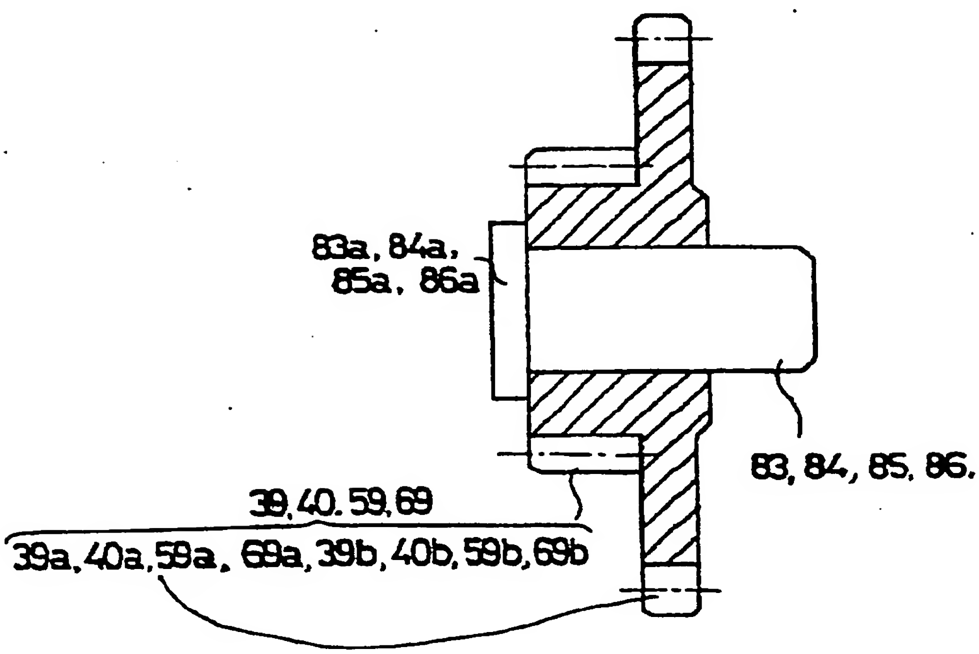

83a, 84a,
85a, 86a
83, 84, 85, 86.
39,40.59,69
39a,40a,59a, 69a,39b,40b,59b,69b

FIG. 25

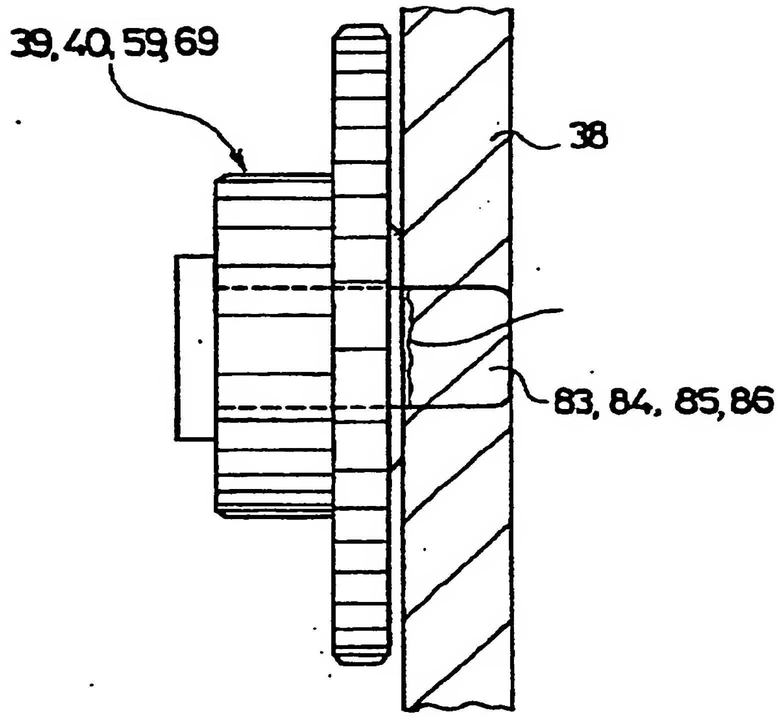


FIG. 26

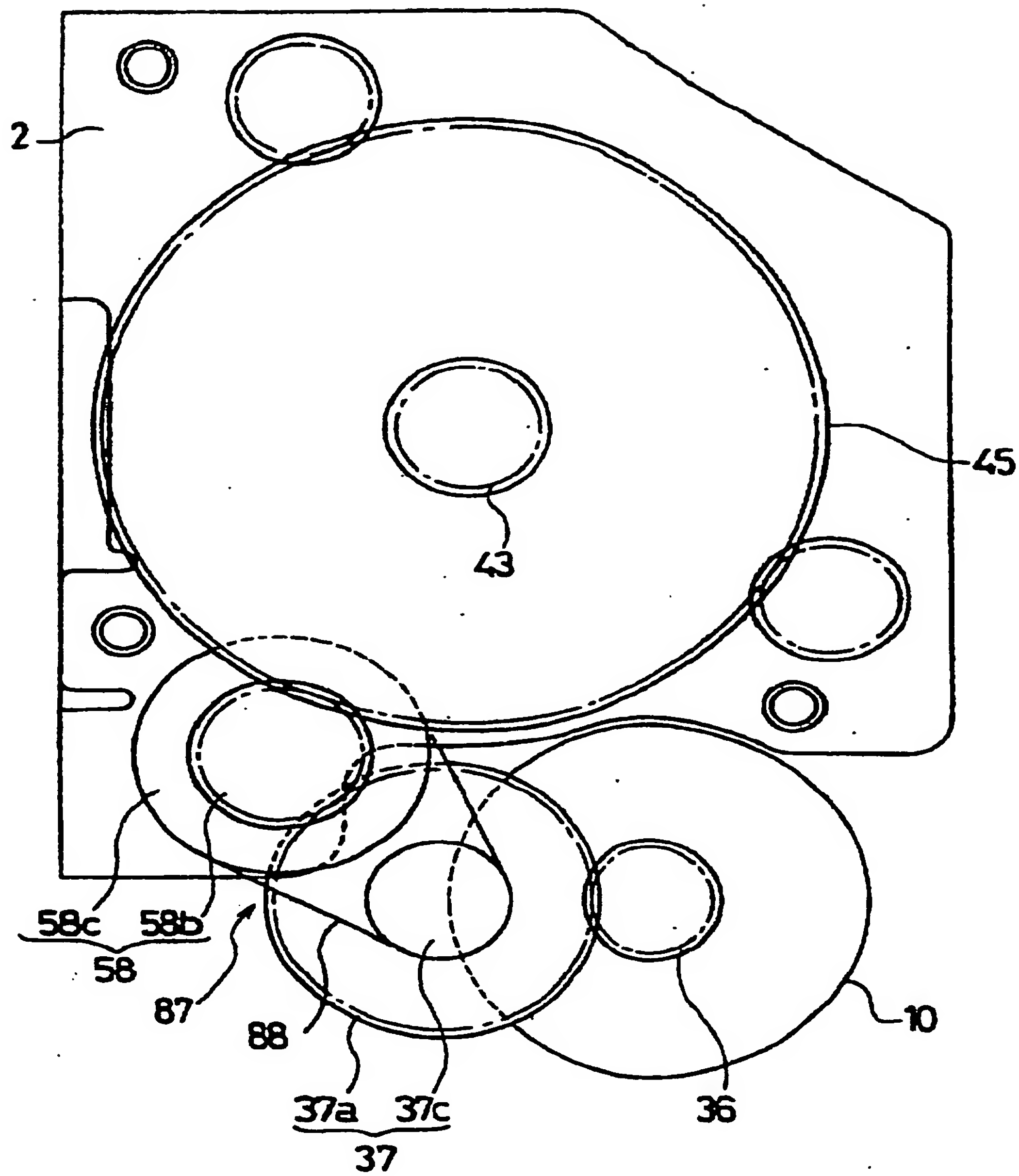


FIG. 27

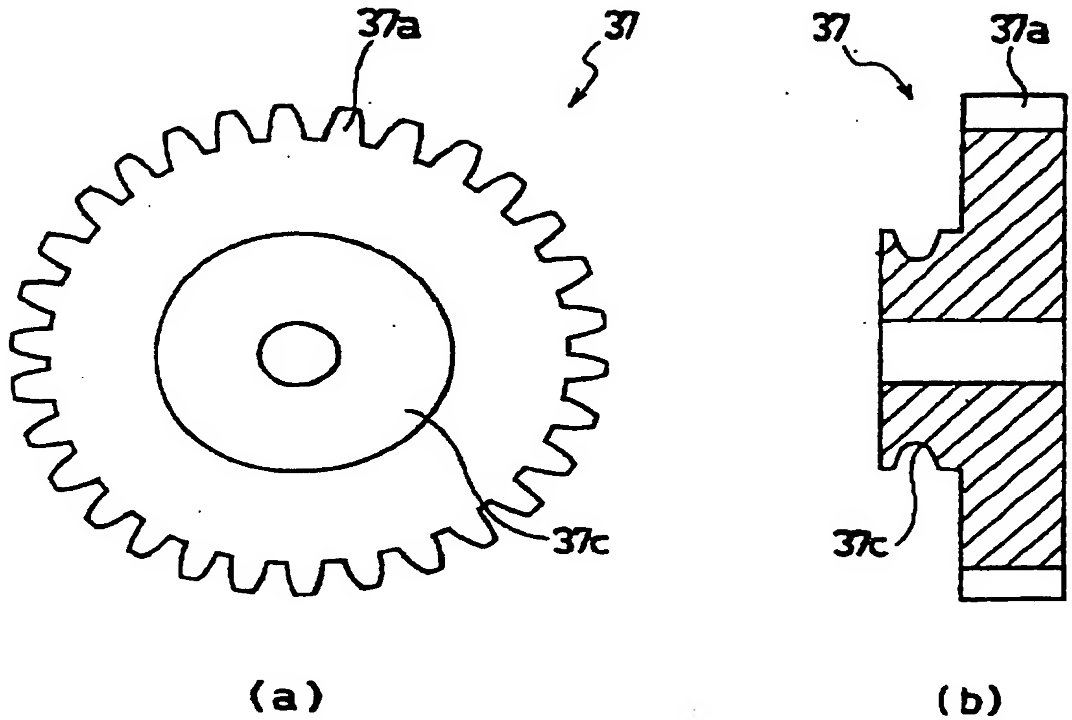


FIG. 28

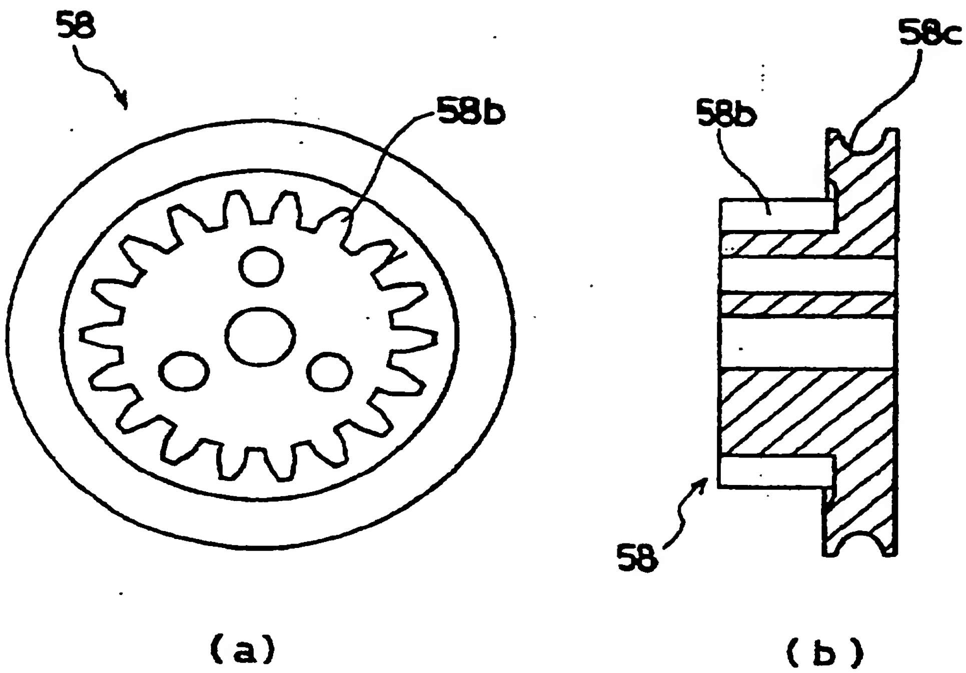


FIG. 29

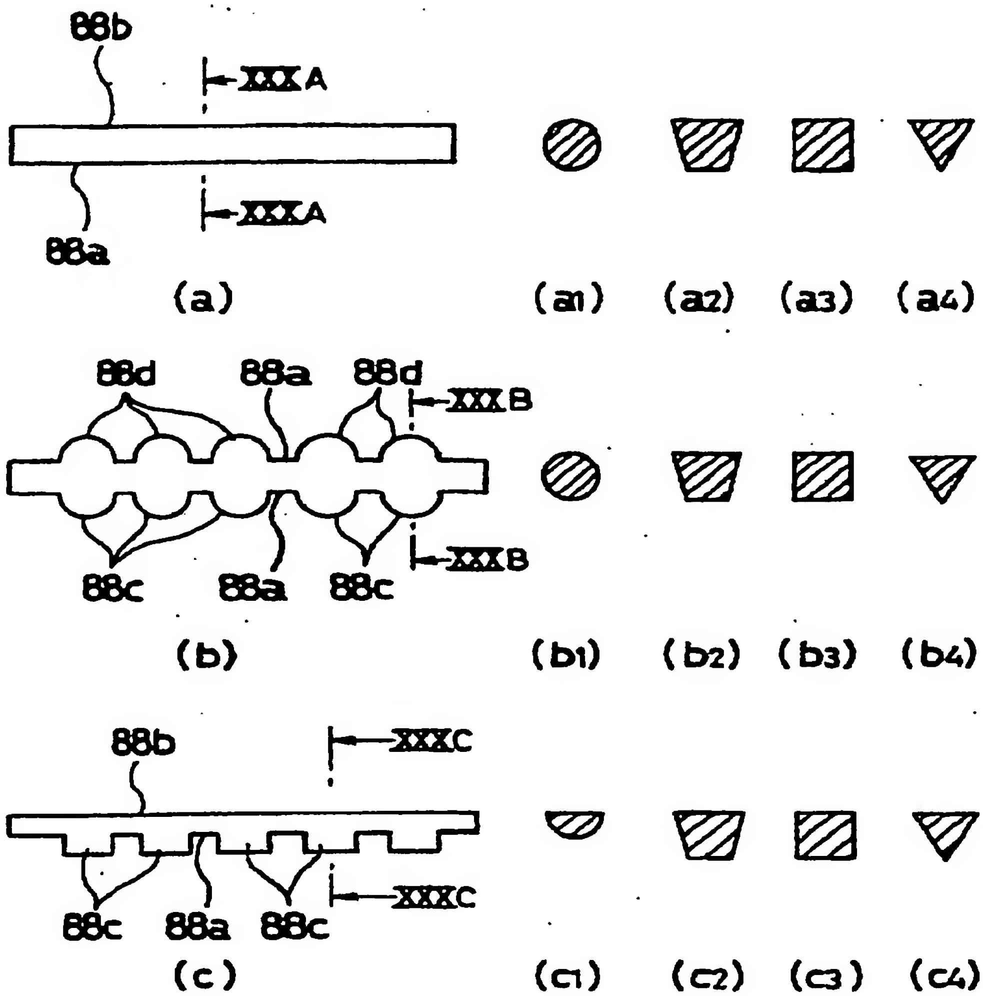

88b
XXXA
88a
XXXA
(a)
(a1)
(a2)
(a3)
(a4)
88d
88a
88d
XXXB
88c
88a
88c
XXXB
(b)
(b1)
(b2)
(b3)
(b4)
88b
XXXC
88c
88a
88c
XXXC
(c)
(c1)
(c2)
(c3)
(c4)

FIG. 30

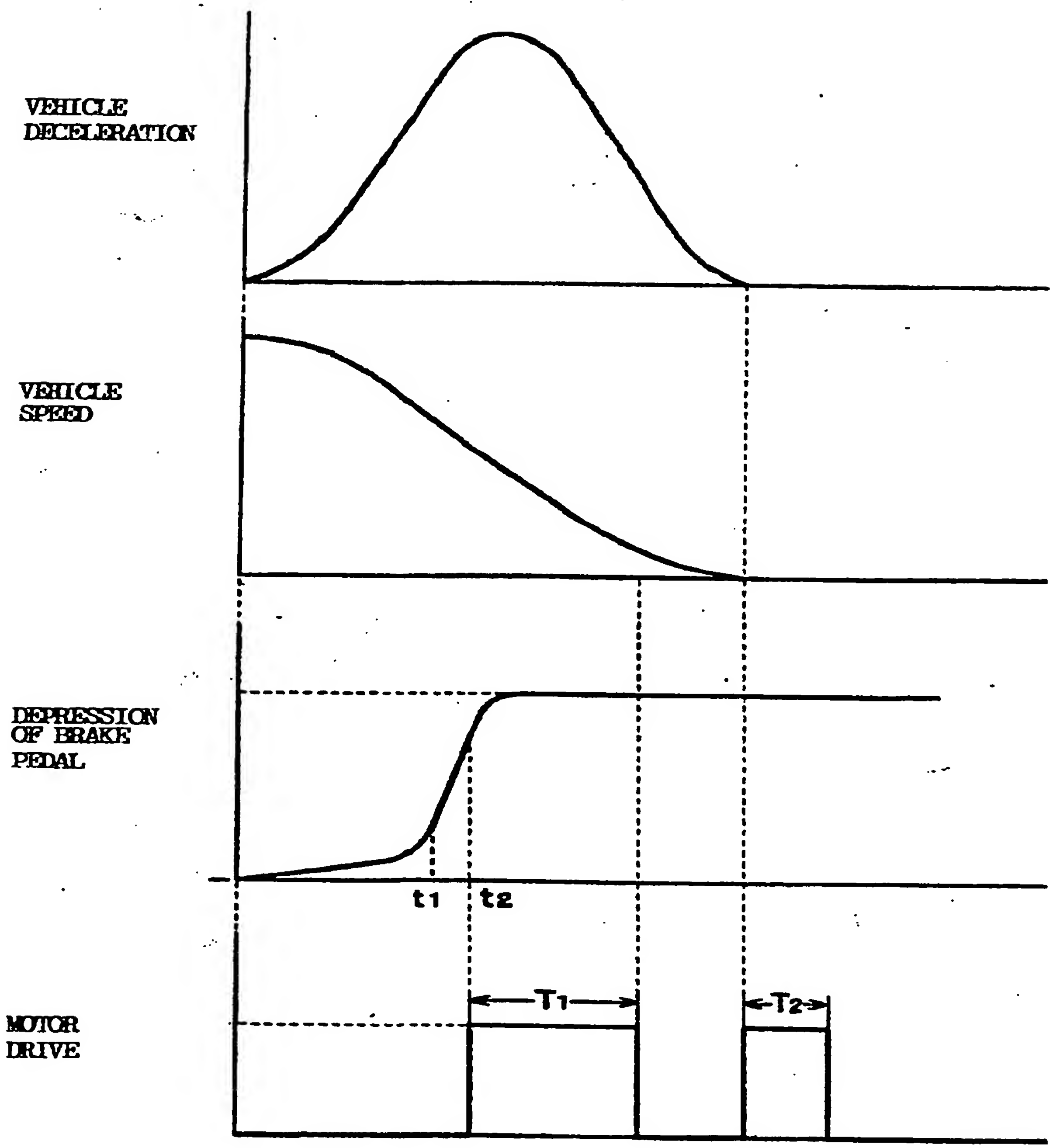

VEHICLE DECELERATION
VEHICLE SPEED
DEPRESSION OF BRAKE PEDAL
t1
t2
MOTOR DRIVE
T1
T2

FIG. 31

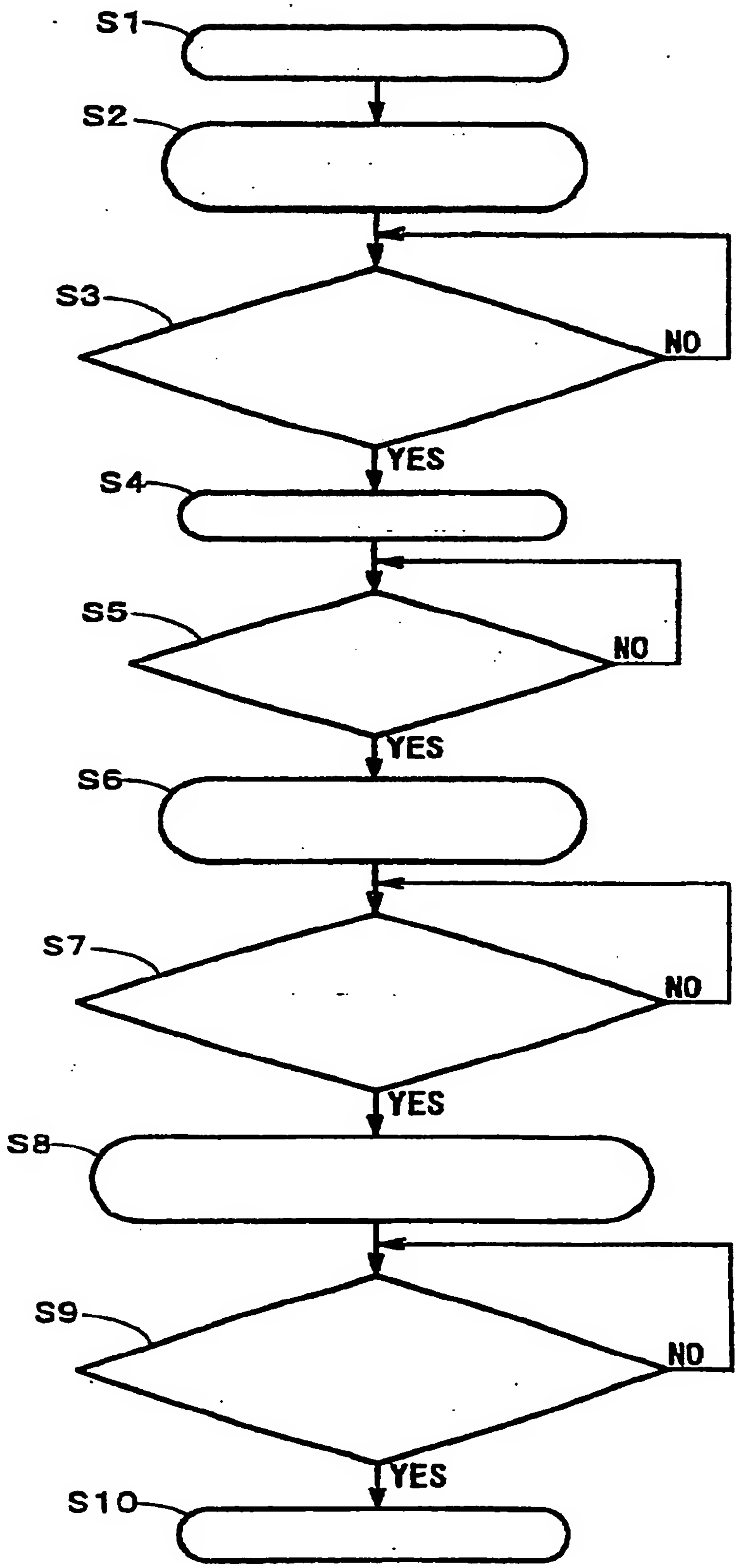
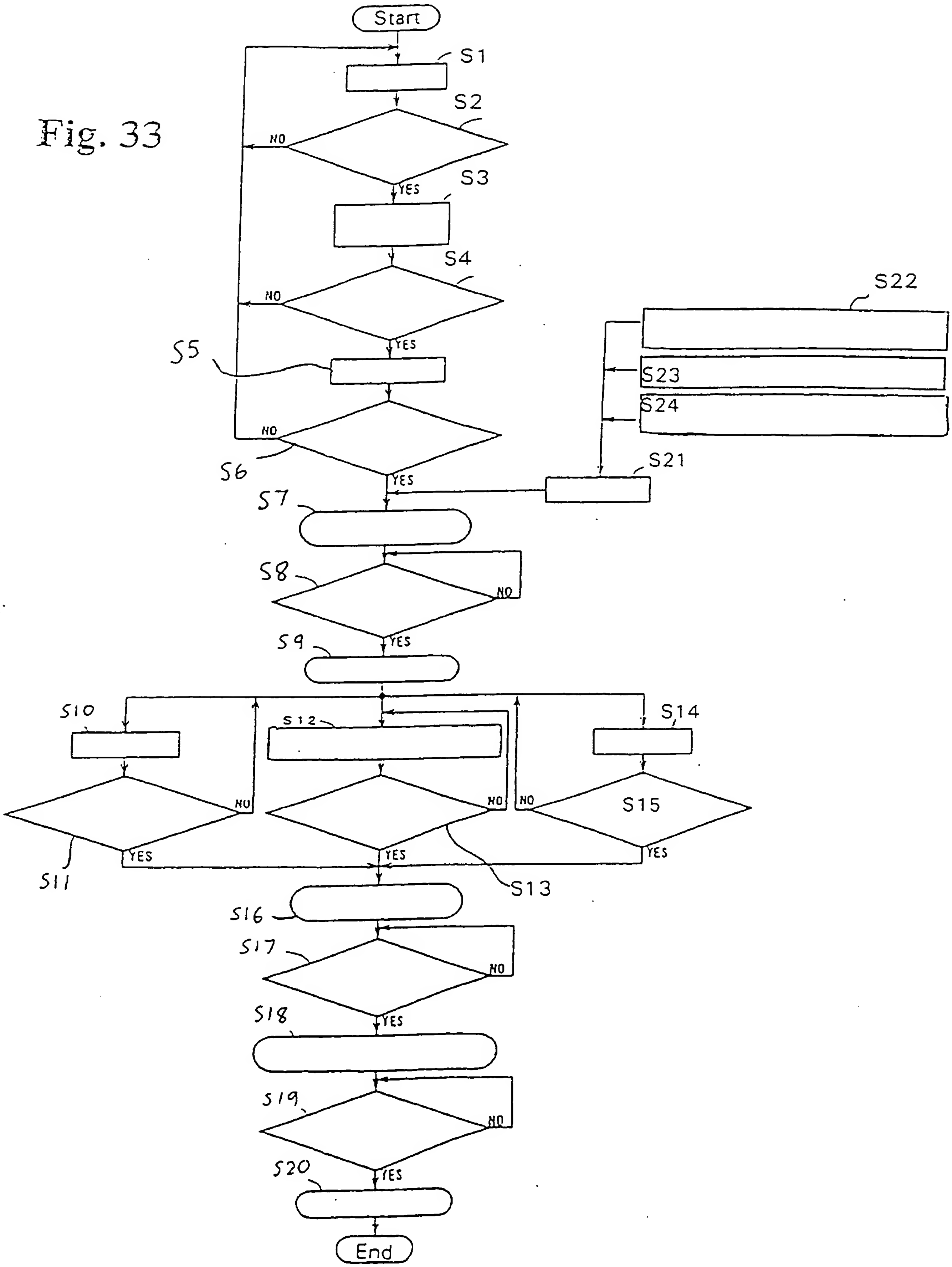


FIG. 32

Fig. 33


Start
S1
S2
NO
YES
S3
S4
NO
YES
S5
NO
S6
YES
S22
S23
S24
S21
S7
S8
NO
YES
S9
S10
S12
S14
NO
NO
NO
S15
YES
YES
YES
S11
S13
S16
S17
NO
YES
S18
S19
NO
YES
S20
End

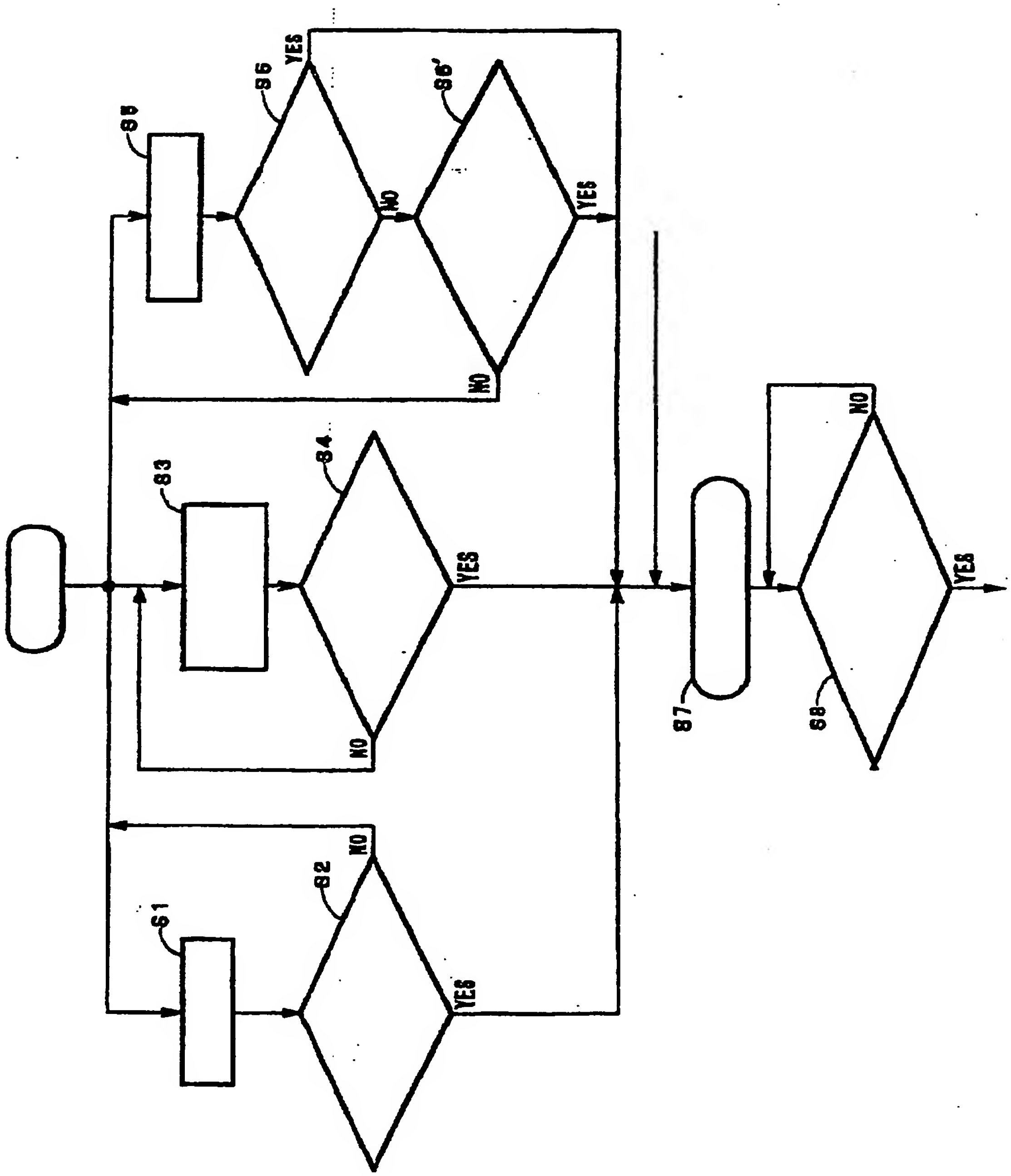


FIG. 34

A SEAT BELT RETRACTOR

The present invention relates to a technological field of a seat belt retractor mounted on the vehicle such as an automotive vehicle, for controlling the unwinding and winding of the seat belt for restraining and protecting a passenger and, more specifically, the invention relates to a technological field of a seat belt retractor for restraining and protecting a passenger more reliably by controlling the tension of the seat belt based on the conditions outside the vehicle or the operating conditions of the seat belt.

The seat belt device that has been mounted conventionally on the vehicle such as an automotive vehicle protects the passenger from being jumped out from the seat in the case of an emergency such that an abrupt deceleration is applied to the vehicle in the event of a collision or the like by restraining the passenger with a seat belt.

The seat belt device of this type is provided with a seat belt retractor for winding the seat belt. The seat belt retractor comprises energy application means such as a flat spiral spring for urging the reel for winding the seat belt all the time in the normal winding direction. The seat belt is wound on the reel by the energy applied by the energy application means when not in use. In contrast, when in use, the seat belt is unwound against the energy applied by the energy application means and worn by the passenger. The seat belt retractor prevents unwinding of the seat belt in case of an emergency as stated above by actuating locking means to prevent the reel from rotating in the unwinding direction. This ensures that the seat belt restrains and protects the passenger in case of an emergency.

In the conventional seat belt device of the type described above, an almost constant tension is applied to the

seat belt by the energy from the energy application means when the seat belt is in use. Therefore, the seat belt retractor always acts in the same manner independently of the conditions between the vehicle itself and the objects surrounding the vehicle. However, though the conventional seat belt device ensures protection of the passenger in case of an emergency as stated above, it cannot be said that it is controlled to be more comfortable for the passenger in the case other than emergency as atated above. In addition, it is preferable to protect the passenger more positively by restraining the passenger securely in case of an emergency.

A passenger restraining and protecting system wherein the restraint and protection of the passenger is carried out more efficiently and more comfortably for the passenger by controlling the rotation of the reel of the seat belt retractor and adjusting the belt tension by a motor with consideration given to the conditions between the vehicle itself and the objects is provided in Japanese Unexamined Patent Application Publication No.9-132113.

On the other hand, when the locking means of the seat belt retractor is actuated in case of an emergency and prevents the reel from rotating in the unwinding direction as atated above, the passenger is tend to move forward by an inertial force and thereby subjected to a significant impact by the seat belt. Therefore, a seat belt retractor comprising a belt load limiting mechanism (EA mechanism) wherein a torsion bar is provided between the reel and the locking means in order to protect the passenger from the impact so that the torsional deformation of the torsion bar absorbs the impact energy and relieves the impact applied to the passenger is also proposed.

Since a number of components are used in the belt tension control mechanism in the passenger restraining and protecting system disclosed in Japanese Unexamined Patent Application Publication No.9-132113, and these components perform complicated actions, the seat belt retractor is significantly upsized and the operational control is complicated.

However, the space in the interior of the vehicle where the seat belt retractor is mounted is limited and quite small, and the space for mounting the seat belt retractor is strictly limited when considering the habitability of the interior of the vehicle. Therefore, it is preferable to provide a seat belt retractor that can accommodate the strict limitation of the mounting space by downsizing it as small as possible, while allowing control of the belt tension based on the conditions between the vehicle itself and the objects.

In addition, since the operational control of the belt tension control mechanism is quite complicated, the drive control of the motor is not simple and, in addition, the drive circuit of the motor is complicated and costly.

In view of such conditions, it is an object of the invention to provide a seat belt retractor wherein the structure of the belt tension control mechanism is further simplified by reducing the number of the components as small as possible, and the control of the belt tension control mechanism is reliable and simple.

In order to overcome the problems described above, the invention is a seat belt retractor comprising at least a reel for winding a seat belt, a reel urging means for urging the reel in the seat belt winding direction, locking means provided between the frame and the reel for allowing rotation of the reel in normal condition, and being actuated to prevent the rotation of the reel in the belt unwinding direction when necessary, and a belt tension control mechanism for controlling the belt tension of the seat belt, characterized in that the belt tension control mechanism comprises a motor for generating a rotational torque, and a power transmission path having the OFF-state in which a rotational torque is not transmitted between the motor and the reel, and the ON-state in which a rotational torque is transmitted between the motor and the reel, and a power transmission path switching mechanism for selectively switching the power transmission path between the ON-state and the OFF-

state, and in that the power transmission path switching mechanism is actuated by a rotational torque of the motor.

The invention may be characterized in that the power transmission path includes a power transmission gear mechanism, in that the power transmission path switching mechanism includes a switchgear axially movable for controlling the operation of the power transmission path switching mechanism, in that the gear of the power transmission gear mechanism and the switchgear are both formed in helical gears and are engaged with respect to each other, and in that when the gear of the power transmission gear mechanism is rotated by a rotational torque of the motor, the switchgear is rotated, and the axial tension generated in the axial direction by the rotation of both gears moves the switchgear in the axial direction, thereby actuating the power transmission path switching mechanism and setting the power transmission path into the ON-state.

The invention may be characterized in that the power transmission path father comprises a speed reducing mechanism for reducing the speed of the rotation of the motor transmitted from the power transmission gear mechanism and transmitting it to the reel, in that the speed reducing mechanism comprises a sun gear, a ring-shaped internal gear rotatably mounted and having ratchet teeth on the outer periphery thereof and internal teeth on the internal periphery thereof, a planetary gear to be engaged with the sun gear and with the internal gear, a carrier for rotatably supporting the planetary gear and transmitting the rotation thereof to the reel, and a speed reducing gear provided so as to rotate with the sun gear as a single piece for receiving the rotation of the motor transmitted from the power transmission gear mechanism, in that the power transmission path switching mechanism further comprises a stop lever being rotatable between the non-engaging position in which the stop lever is not engaged with the ratchet teeth and the engaging position in which the stop lever is engageable with the ratchet teeth, and a plunger for placing said stop lever to the non-engaging position in the normal state in which the switchgear does not

move in the axial direction to allow the free rotation of the internal gear and for preventing the rotation of the internal gear, when actuated by the movement of the switchgear in the axial direction, by placing the stop lever to the engaging position so that the stop lever is engaged with the ratchet teeth, and in that the power transmission path is set to the OFF-state when the internal gear is free to rotate, and is set to the ON-state when the internal gear is prevented from rotating.

The invention may be characterized in that the power transmission path includes a power transmission gear mechanism, and the power transmission path switching mechanism includes a control lever being rotatable for controlling the operation of the power transmission path switching mechanism, and in that when the gear of the power transmission gear mechanism is rotated by a rotational torque of the motor, the power transmission path switching mechanism is actuated by the rotation of said rotatable control lever so that the power transmission path is set to the ON-state.

The invention may be characterized in that the power transmission path further comprises a speed reducing mechanism for reducing the speed of the rotation of the motor transmitted from the power transmission gear mechanism and transmitting it to the reel, in that the speed reducing mechanism comprises a sun gear, a ring-shaped internal gear rotatably mounted and having ratchet teeth on the outer periphery and internal teeth on the inner periphery, a planetary gear to be engaged with the sun gear and the internal gear, a carrier for rotatably supporting the planetary gear and transmitting the rotation thereof to the reel, and a speed reducing gear provided so as to rotate with the sun gear as a single piece for receiving the rotation of the motor transmitted from the power transmission gear mechanism, in that the power transmission path switching mechanism further comprises a stop lever being rotatable between the non-engaging position in which the stop lever is not engaged with the ratchet teeth and the engaging position in which the stop lever is engageable with the ratchet teeth, so that, in the normal

state in which the control lever does not rotate, the stop lever is placed into the non-engaging position to allow the free rotation of the internal gear, and when the control lever is rotated, the stop lever is placed to the engaging position and engaged with the ratchet teeth to prevent the rotation of the internal gear, and in that in the state in which the internal gear is free to rotate, the power transmission path is set to OFF-state and in the state in which the rotation of the internal gear is prevented, the power transmission path is set to the ON-state.

In addition, the invention may be characterized in that the control lever comprises a lever spring having a prescribed resiliency.

The invention may be characterized in that the planetary gear comprises a large planetary gear having a large diameter and engaging with the sun gear all the time, and a small planetary gear having a diameter smaller than the large planetary gear provided so as to rotate with the large planetary gear as a single piece, and engaging the internal teeth of the internal gear all the time.

The invention may be characterized in that the braking mechanism is provided with a transmitted torque limiting mechanism that discontinues transmission of a power when a power transmission torque is equal to or higher than the prescribed value.

The invention may be , characterized in that the transmitted torque limiting mechanism is composed of a supporting portion of the planetary gear that is ruptured when a power transmission torque is equal to or higher than the prescribed value.

The invention may be characterized in that the power transmission gear mechanism includes a belt power transmission mechanism comprising a first and a second pulleys and an endless belt looped between the first and the second pulleys, and in that the belt power transmission mechanism is provided with a transmitted torque limiting mechanism that discontinues power transmission by generating a

slip between the endless belt and at least one of the first and the second pulleys when a power transmission torque is equal to or higher than the prescribed value.

The invention also provides a seat belt retractor comprising at least a reel for winding a seat belt, locking means provided between the frame and the reel for allowing rotation of the reel in normal condition and being actuated to prevent the rotation of the reel in the belt unwinding direction when necessary, and a belt tension control mechanism for controlling the belt tension of the seat belt, characterized in that the belt tension control mechanism comprises a motor for generating a rotational torque, a power transmission path for transmitting a rotational torque between the motor and the reel, vehicle's emergency state detecting means for detecting the emergency state of the vehicle and sending signals, and motor drive control means for driving the motor in the belt winding direction for the first preset time period according to the signal from the vehicle's emergency state detecting means to restrain the passenger, then stopping the operation of said motor, and when the prescribed conditions are satisfied after said motor has stopped, driving said motor again in the belt winding direction additionally for the second preset time period.

In addition, the invention may be characterized in that said vehicle's emergency state detecting means detects that the vehicle is in the emergency state when it determines that three conditions, that is, the condition that the speed of the vehicle is equal to or higher than the first fixed speed, the condition that the speed of depression of the brake pedal is equal to or higher than a fixed speed of depression, and the condition that the deceleration of the vehicle is equal to or higher than the first fixed deceleration are all satisfied.

In addition, the invention may be characterized in that said vehicle's emergency state detecting means detects that the vehicle is in the emergency state when the condition that the speed of the vehicle is equal to or higher than the first fixed speed is determined to be satisfied,

when the condition that the speed of depression of the brake pedal is equal to or higher than the fixed speed of depression is determined to be satisfied, or when the condition that the acceleration of the vehicle is equal to or higher than the first fixed acceleration which is a positive value, or is equal to or lower than the second fixed acceleration which is a negative value is determined to be satisfied.

The invention may be characterized in that said prescribed condition is one of the condition that the vehicle has stopped, the condition that the speed of the vehicle is equal to or lower then the second fixed speed, the condition that the deceleration of the vehicle is equal to or lower than the second fixed deceleration, and the condition that the time elapsed from moment when the operation of the motor is stopped is equal to or longer than the ~~third~~ preset time period.

In addition, the invention may be characterized in that said motor is driven in the belt unwinding direction for the third preset time period after said motor is driven in the belt winding direction for said second preset time period.

In the seat belt retractor in this arrangement according to the present invention, ON and OFF-states of the power transmission path between the reel and the motor is selectively switched by the power transmission switching mechanism operationally controlled by a driving force of the motor. In other words, when the motor is not in operation, the power transmission path switching mechanism is not actuated, the power transmission path is set to OFF-state, and thus a rotational torque is not transmitted between the motor and the reel. Therefore, when the seat belt is drawn out and the reel rotates in the belt unwinding direction, or when the reel rotates in the belt winding direction during belt winding operation after the seat belt is unwound, the rotation of the reel is not transmitted to the motor and the power transmission path switching mechanism, and the motor and the power transmission path switching mechanism is not affected by the

rotation of the reel.

When the motor is in operation, a rotational torque of the motor actuates the power transmission path switching mechanism, the power transmission path is set to the ON-state, and a rotational torque is transmitted between the motor and the reel. Therefore, rotational torque of the motor is transmitted to the reel via the power transmission path switching mechanism to rotate the reel, and the winding and unwinding of the seat belt is carried out to control the belt tension. In this way, the belt tension is controlled to a prescribed value by the belt tension control mechanism actuated by a driving force of the motor.

In this case, since ON and OFF-states of the power transmission path is controlled by the power transmission path switching mechanism operated by rotational torque of the motor, a specifically designed actuator driven by other motive power such as electromagnetic solenoid or the like for actuating the power transmission path switching mechanism is not required. Therefore, the power transmission path switching mechanism has less number of components and is simpler in structure, and thus the cost is further reduced.

According to claim 8 of the invention, when a power transmission torque is equal to or higher than the prescribed value, the transmitted torque limiting mechanism discontinues transmission of a power. Accordingly, sudden increase in a power transmitted in case of an emergency discontinues transmission of a power, whereby a load of the motor itself is not linked to the reel side. Therefore, as described above, in the seat belt retractor having the EA mechanism on the reel side, the load of the motor itself is not linked to EA mechanism. As a consequent, increase in a load applied to the EA mechanism due to the load of the motor itself (the EA load) is controlled. In this case, according to the invention as set forth in claim 9, the structure of the transmitted torque limiting mechanism is simpler because the supporting portion of the planetary gear is constructed to be ruptured to discontinue transmission of a power when a power transmission torque is

equal to or higher than the prescribed value.

In the invention as set forth in claim 10, when a power transmission torque is equal to or higher than the prescribed value, a slip generated between the endless belt and the pulley discontinues transmission of a power. Accordingly, as described above, even when the power transmitted increases suddenly, transmission of the power is discontinued, so that the high load of the motor itself is not linked to the reel side. Therefore, in the seat belt retractor including the EA mechanism on the reel side as in the case of claim 8 described before, the high load of the motor itself is not linked to the EA mechanism. Consequently, increase in the belt limiting load due to the high load of the motor itself can be controlled.

In addition, since it is not constructed in such a manner that the component of the power transmission mechanism such as a supporting portion of the planetary gear is ruptured when a power transmission torque is equal to or higher than the prescribed value, when a power transmission torque has lowered to the prescribed value or below, the component can be used repeatedly. Therefore, in the vehicle that can drive freely even after occurrence of an emergency such as a crush, when another emergency such as a secondary crush occurred again while the vehicle is being driven to another location such as a repair shop, the capability of the seat belt retractor to restrain the passenger by winding its seat belt by the motor may be fully exerted again.

According to the invention as set forth in claim 11, when the emergency state of the vehicle is detected, the motor is driven in the belt winding direction for the first preset time period to restrain the passenger. Then when the prescribed conditions are satisfied after the stoppage of the motor, the motor is driven again in the belt winding direction additionally for at least the second preset time period. Consequently, after the locking means is actuated by occurrence of the vehicle's emergency and then the emergency state is eliminated, the actuation of the locking means is automatically released. Therefore, the passenger is released easily and more reliably from the state of secure restraint brought by the

motor being driven in the belt winding direction. In addition, it is not necessary to release the engagement between the tongue and the buckle every time as in the case of the conventional system any more, whereby the additional lock releasing operation to be made by the passenger can be eliminated.

Especially, in the invention as set forth in claim 12, detection of the vehicle's emergency state can be performed in further detail and more accurately by detecting the vehicle's emergency state only when all of these three conditions are satisfied.

In the invention as set forth in claim 13, detection of the vehicle's emergency state by the vehicle's emergency state detecting means is relatively easy since the vehicle's emergency state detecting means detects that the vehicle is in the emergency state when the condition that the speed of the vehicle is equal to or higher than the first fixed speed is determined to be satisfied, when the condition that the speed of depression of the brake pedal is equal to or higher than a fixed speed of depression is determined to be satisfied, or when the condition that the acceleration of the vehicle is equal to or higher than the first fixed acceleration which is a positive value, or is equal to or lower than the second fixed acceleration which is a negative value is determined to be satisfied.

In the invention as set forth in claim 14, it is determined that the vehicle's emergency state is eliminated when one of the condition that the vehicle has stopped, the condition that the speed of the vehicle is equal to or lower then the second fixed speed, the condition that the deceleration of the vehicle is equal to or lower than the second fixed deceleration, and the condition that the time elapsed from the stoppage of the motor is equal to or longer than the third preset time period. Consequently, the operation of the locking means is automatically released at an earlier stage and more flexibly after the vehicle's emergency state is eliminated.

In the invention as set forth in claim 15, after the

vehicle's emergency state is eliminated and the operation of the rocking means is automatically released, the seat belt is restored automatically to the state as it was before the vehicle's emergency state was detected. Consequently, the passenger does not need to perform the additional lock releasing operation, and what is more, he or she can be released automatically from the restrained state.

Examples of the present invention will now be described in detail with reference to the accompanying drawings. Details of what the drawings show are listed below:

[Fig. 1] An exploded perspective of the seat belt retractor according to an example of the embodiments of the invention.

[Fig. 2] A partly enlarged exploded perspective view showing a part of the seat belt retractor shown in Fig. 1 being enlarged.

[Fig. 3] A partly enlarged exploded perspective view showing another part of the seat belt retractor shown in Fig. 1 being enlarged.

[Fig. 4] A partly enlarged exploded perspective view showing still another part of the seat belt retractor shown in Fig. 1 being enlarged.

[Fig. 5] A longitudinal section of the seat belt retractor of the example shown in Fig. 1, showing the assembled state as seen from the side of the locking means.

[Fig. 6] A longitudinal section of the seat belt retractor of the example shown in Fig. 1, showing the assembled state as seen from the side of the spring means.

[Fig. 7] An explanatory drawing, illustrating the operation of a switchgear used in the seat belt retractor shown in Fig. 1, wherein (a) is a switchgear in the non-operating mode, as seen from the same direction as the direction of axis of the reel, (b) is a partly sectional view taken along the line VIIB-VIIB shown in (a), (c) is a switchgear in operating mode, as seen from the same direction as the direction of axis of the reel, and (d) is a partly sectional view taken along the line VIID-VIID shown in (c).

[Fig. 8] A side view showing the motor, the power transmission gear mechanism, the speed reducing mechanism, and the power transmission path switching mechanism used in the seat belt retractor shown in Fig. 1 in non-operating mode being

partly broken away.

[Fig. 9] A side view showing the motor, the power transmission gear mechanism, the speed reducing mechanism, and the power transmission path switching mechanism used in the seat belt retractor shown in Fig. 1 in operating mode being partly broken away.

[Fig. 10] An exploded perspective view showing the seat belt retractor in another example of the embodiments according to the invention.

[Fig. 11] A partly enlarged exploded perspective view showing a part of the example shown in Fig. 10 being enlarged.

[Fig. 12] A partly enlarged exploded perspective view showing another part of the example shown in Fig. 10 being enlarged.

[Fig. 13] A partly enlarged exploded perspective view shoeing still another part of the example shown in Fig. 10 being enlarged.

[Fig. 14] A side view of the motor, the power transmission gear mechanism, the speed reducing mechanism, and the power transmission path switching mechanism used in the seat belt retractor of the example shown in Fig. 10 being partly broken away.

[Fig. 15] An explanatory side view as in Fig. 14 illustrating the operation of the seat belt retractor in the state in which the seat belt is wound by a driving force of the motor.

[Fig. 16] An explanatory side view as in Fig. 14 illustrating the operation of the seat belt retractor in the state in which the seat belt winding operation is released by a driving force of the motor.

[Fig. 17] An exploded perspective view showing the seat belt retractor of the third example according to the embodiment of the present invention.

[Fig. 18] A side view showing only the motor and the power transmission gear mechanism used in the seat belt retractor shown in Fig. 17.

[Fig. 19] A drawing of a carrier used in the seat belt retractor shown in Fig. 17, wherein (a) is a front view, (b) is a cross-sectional view taken along the line XIXB-XIXB of the figure (a), and (c) is a rear view.

[Fig. 20] An explanatory view illustrating the operation of the torque transmission limiting mechanism in the seat belt retractor shown in Fig. 17.

[Fig. 21] A drawing of a reduction pin used in the seat belt retractor shown in Fig. 17, wherein (a) is a front view, (b) is a longitudinal section of (a), and (c) is a rear view.

[Fig. 22] A drawing of a planetary gear used in the seat belt retractor of the embodiment of the present invention, wherein (a) is a front view, (b) is a cross-sectional view taken along the line XXIIB-XXIIB of the figure (a).

[Fig. 23] A drawing of a carrier used in the seat belt retractor of the fourth example, wherein (a) is a front view, and (b) is a longitudinal section.

[Fig. 24] An explanatory drawing illustrating the operation of the torque transmission limiting mechanism of the seat belt retractor of the fourth example.

[Fig. 25] A cross-sectional view of a planetary gear used in the seat belt retractor, and a supporting pin of the fifth example according to the embodiment of the present invention.

[Fig. 26] An explanatory drawing illustrating the operation of the torque transmission limiting mechanism in the seat belt retractor of the fifth example.

[Fig. 27] A side view showing only a motor and a power transmission gear mechanism used in the seat belt retractor of the sixth example according to the embodiment of the present invention.

[Fig. 28] A drawing of a connect gear used in the seat belt retractor of the sixth example shown in Fig. 27, wherein (a) is a front view, and (b) is a longitudinal section.

[Fig. 29] A drawing of an intermediate speed reducing gear used in the seat belt retractor of the sixth example shown in Fig. 27, wherein (a) is a front view, and (b) is a longitudinal cross-section.

[Fig. 30] A partial drawing of the endless belt used in the seat belt retractor of the sixth example shown in Fig. 27, wherein (a) to (c) are drawings showing endless belts in various configurations respectively.

[Fig. 31] A drawing of the seventh example according to the embodiment of the present invention.

[Fig. 32] A flow chart showing a driving control of the

motor of the seventh example shown in Fig. 31.

[Fig. 33] A flow chart showing the driving control of the motor shown in the eighth example according to the embodiment of the invention.

[Fig. 34] A flow chart showing the driving control of the motor shown in the ninth example according to the embodiment of the invention.

Referring now to the drawings, the embodiment of the invention will be described.

Fig. 1 is an exploded perspective view of the seat belt retractor according to the first example of the embodiments of the invention, Figs. 2 to 4 are partly enlarged exploded perspective view showing the seat belt retractor of Fig. 1 partially enlarged, Fig. 5 is a longitudinal section of the seat belt retractor of the first example showing the assembled state as seen from the side of the locking means, and Fig. 6 is a longitudinal section of the seat belt retractor of the first example in the assembled state showing the side of the spring means.

As shown in Fig. 1, the seat belt retractor 1 of the first example comprising, broadly dividing, a frame 2, a reel 4 for winding the seat belt 3, locking means 5 provided on one side of the frame 2 for preventing the rotation of the reel 4 in the belt unwinding direction CW when in use, a lock actuating mechanism 6 for actuating the locking means 4 when necessary, a force limiter mechanism (hereinafter referred to as "EA mechanism") 7 for limiting the load of the seat belt when the unwinding of the seat belt is prevented by the action of the locking means 5 in the event of abrupt speed reduction such as collision, speed reduction detecting means 8 for detecting the speed reduction of the vehicle, a motor 10 for generating a rotational torque, a power transmission gear mechanism 11 for transmitting a rotational torque of the motor 10, a speed reducing mechanism 12 for reducing the speed of a rotational torque of the motor 10 transmitted from the power transmission gear mechanism 11 and transmitting it to the reel 4, a power transmission path switching mechanism 13 for

selectively switching to one of the state in which rotational torque of the motor 10 is transmitted to the reel 4 and the state in which the rotation of the motor 10 is not transmitted to the reel 4, and spring means 14 for urging the reel 4 in the winding direction CCW of the seat belt 3.

Although the components of the seat belt retractor 1 are shown in three rows in an exploded perspective view in Fig. 1, actually, the end A_1 of the straight line passing through the centers of the upper locking means 5 and the lock actuating mechanism 6 respectively on the side of the locking means is connected to the end A_1 of the straight line A_1-A_2 passing through the frame 2, and the end A_2 of the straight line passing through the centers of the lower speed reducing mechanism 12 and the spring means 14 respectively on the side of the speed reducing mechanism 12 is connected to the end A_2 of the straight line A_1-A_2 passing through the frame 2.

As shown in Fig. 2, the frame 2 comprises a pair of parallel sidewalls 15 and 16 and a back plate 17 connecting the sidewalls 15 and 16. Between both sidewalls 15 and 16, there is disposed a reel 4 for winding the seat belt 3.

One of the sidewalls 15 is formed with a circular large opening 15a. The other one of the sidewalls 16 is also formed with a circular large opening 16a concentrically with respect to the large opening 15a, and is fixed with an internal teeth member 18 having a circular opening with a prescribed number of internal teeth 18a in the shape of ratchet teeth on the surface of the internal periphery thereof with the internal teeth 18a registered concentrically with respect to the large opening 16a. In addition, the sidewall 16 is further provided with a mounting hole for mounting the speed reduction detecting means 8.

The reel 4 comprises a seat belt winding portion 4a for winding the seat belt 3, and a flange portions 4b and 4c located on both ends of the seat belt winding portion 4a, and a through hole 4d that extends in the axial direction formed on the center thereof. In this case, the through hole 4d is formed in such a manner that the end on the side of the

sidewall 15 is formed into the hexagonal shape in cross section, and the end on the side of the sidewall 16 has a cross section that allows the stop 27 described later to be fitted and allows the reel 4 and the stop 27 to rotate as a single piece.

As shown in Fig. 3, the locking means 5 comprises a locking base 19 and a pawl 20. The locking base 19 comprises a disk portion 19a and a threaded shaft portion 19b, and provided with a through hole 19c axially piecing the center thereof. The portion of the through hole 19c corresponding the disk portion 19a is a hole of regular hexagonal cross section 19c'. The disk portion 19a is provided with a hole 19d for rotatably supporting the pawl 20, and a arc-shaped load-transmitted portion 19e that is concentric with the hole 19d. The load-transmitted portion 19e undergoes a load from the pawl 20. On the portion of the outer periphery of the disk portion 19a opposite to the load transmitted portion 19e, there is formed knurled teeth 19f along a prescribed range, and the knurled teeth 19f are engageable with the internal teeth 18a of the internal teeth member 18. In addition, the disk portion 19a is provided with a spring supporting portion 19g for supporting one end of the pawl spring 25 described later.

On the other hand, the pawl 20 comprises a hole 20a formed on the proximal end of rotation, and rotatably mounted on the locking base 19 by fitting a fixture such as a pin, not shown, into the hole 20a and a hole 19d formed on the locking base 19. On the tip of the pawl 20, there is formed a stop claw 20b engageable with the internal teeth 18a of the internal teeth member 18 and provided a cam follower 20c formed of a protruding strut. In addition, the pawl 20 is formed with an arc-shaped load transmitting portion 20d, which transmits the reaction acting on the pawl 20b to the load-transmitted portion 19e of the locking base 19. In other word, the reaction of the pawl 20b is supported by the locking base 19.

The lock actuating mechanism 6 comprises a lock gear 21, a flywheel 22, a flywheel spring 23 compressively mounted between the lock gear 21 and the flywheel 22, a first retainer 24 removably fixed on the sidewall 16 of the frame 2, and a

pawl spring 25 compressively mounted between the locking base 19 and the lock gear 21.

The lock gear 21 comprises a disk portion 21a, and an annular teeth member 21c having a prescribed number of the external teeth 21b in the shape of ratchet teeth formed on the outer periphery thereof.

In the center of the disk portion 21a, there are formed a cylindrical boss 21d and a supporting shaft 21e protruding for rotatably supporting the flywheel 2 in the vicinity of the boss 21d. In addition, on the side of the outer periphery of the disk portion 21a, there are provided a first and second stops 21f and 21g for limiting the rotation of the flywheel 22 to a prescribed range, and a cam hole 21h formed through the disk portion 21a. The cam hole 21h is fitted with the cam follower 20c of the pawl 20, so that the cam follower 20c is guided to the cam hole 21h to rotate the pawl 20 when the lock gear 21 is rotated with respect to the locking base 19. In addition, the disk portion 21a is provided with a spring supporting portion 21i for supporting one end of the pawl spring 25.

The flywheel 22 is provided with a supporting hole 22a rotatably fitted with the supporting shaft 21e of the lock gear 21, and a stopper portion 22c formed with a stop claw 22b on the tip thereof. When the flywheel is rotatably supported on the supporting hole 22a, the stopper portion 22c is positioned between the first and the second stops 21f and 21g. Therefore, the rotation of the flywheel 22 is limited to the portion between the first and second stops 21f and 21g, so that the stop claw 22b assumes the state being retracted radially inside while the stopper portion 22c is in contact with the first stop 21f, and the stop claw 22b assumes the state projecting radially outside while the stopper portion 22c is in contact with the second stop 21g. In addition, the flywheel 22 is provided with a spring supporting portion 22d for supporting one end of the flywheel spring 23.

The flywheel spring 23 is supported by the spring supporting portion 22d of the flywheel 22 on one end and by the spring supporting portion, not shown, of the lock gear on the

other end, so that the flywheel 22 is urged in the belt unwinding direction CW with respect to the lock gear 21 all the time. Therefore, when the flywheel 22 is not in operation, the stopper portion 22c remains in contact with the first stop 21f.

The first retainer 24 comprises a disk portion 24a, a first annular flange portion 24b formed on the outer periphery of the disk portion 24a projecting toward the side where the frame 2 resides for being fixed removably on the sidewall 16 (shown in Fig. 5), and a second annular flange portion 24c formed on the outer periphery of the disk portion 24a projecting toward the opposite side of the frame 2.

The center of the disk portion 24a is formed with a through hole 24d. As shown in Fig. 5, the surface of the disk portion 24a facing the frame 2 is provided with an annular teeth member 24f having the internal teeth 24e in the shape of ratchet teeth on the internal periphery and projecting concentrically with the through hole 24d. The annular teeth member 24f is sized so as to be able to be inserted between the first and the second stops 21f and 21g. In this case, the stop claw 22c of the flywheel 22 is also placed within the annular teeth member 21c, so that the stop claw 22c is engaged with the internal teeth 24e when the flywheel 22 is rotated with respect to the lock gear 21 into the position in which the stop portion 22c comes into contact with the second stop 21g. The second annular flange portion 24c is provided with a first cover 34 removably mounted thereon.

The pawl spring 25 is supported by the spring supporting portion 21i of the lock gear 21 on one end and by the spring supporting portion 19g of the locking base 19 on the other end, so as to urge the lock gear 21 with respect to the locking base 19 in the belt unwinding direction CW all the time. Therefore, when the lock gear 21 is not in operation, the cam follower 20c of the pawl 20 is positioned at the innermost position $21h_1$ of the cam hole 21h, and in this state, the lock gear 21 is prevented from further rotation caused by the pawl spring 25.

The EA mechanism 7 comprises a torsion bar 26 and a

cylindrical stop 27 screwed onto the threaded shaft portion 19b of the locking base 19. The torsion bar 26 comprises a torsion bar portion 26a, a first torque transmitting portion 26b provided on one end of the torsion bar portion 26a on the side of the lock gear 21 and being regular hexagonal in cross section to be fitted into the hole of regular hexagonal cross section 19c' formed on the locking base 19 so as not to rotate with respect to the locking base 19, a flange portion 26c provided on the end of the first torque transmitting portion 26b, a second torque transmitting portion 26d of regular hexagonal cross section provided on the other end of the torsion bar portion 26a, a first shaft portion 26f concentrically projecting from the second torque transmitting portion 26d and being formed with a spline groove 26e on the tip thereof, and a second shaft portion 26h concentrically projecting from the flange portion 26c and being formed with a spline groove 26g thereon.

The cylindrical stopper 27 is provided, on the inner periphery thereof, with a female screw 27a to be screwed on the threaded shaft portion 19b of the locking base 19, and on the outer periphery thereof, with a pair of rotational torque transmitting portions 27b and 27c respectively for receiving rotational torque transmitted from the reel 4. By providing the rotational torque transmitting portions 27b and 27c, the stop 27 is rotatable with the reel 4 as a single piece and axially movable with respect to the reel 4. Therefore, when the rotational differential such that the stop 27 rotates with respect to the locking base 19 in the belt unwinding direction CW is generated, in other words, when the rotational differential such that the reel 4 rotates with respect to the locking base 19 in the belt unwinding direction CW is generated, the stop 27 moves in the direction of axis and is brought into contact with the disk portion 19a of the locking base 19. When the stop 27 comes into contact with the locking base 19, the stop 27 stops moving in the direction of axis and rotates with the locking base 19 as a single piece.

Therefore, since the torsion bar portion 26a is twisted while the rotational differential exists between the stop 27

and the locking base 19, the EA mechanism 7 exerts its EA function that limits the belt load in the event of collision of the vehicle, and when the stop 27 comes into contact with the locking base 19, the EA function is terminated. In this way, the region where the EA function is performed is defined by the stop 27 and its female screw 27a, and the locking base 19 and its threaded shaft portion 19b.

As shown in Fig. 2, the speed reduction detecting means 8 comprises a housing 28 to be mounted on the sidewall 16, a sensor case 29 to be mounted on the housing 28, an inertial mass 30 to be mounted on the sensor case 29, and an actuator 31 actuated by the inertial mass 30.

The housing 28 comprises a fitting portion 28a for fixing to the sidewall 16 of the frame 2 by fitting into the mounting hole 16b formed thereon, and a pair of supporting arm portions 28b and 28c for supporting the sensor case 29. The sensor case 29 comprises a pair of supported portions 29a and 29b to be supported by engagement with the grooves formed on the supporting arm portions 28b and 28c, a mass mounting portion 29c on which the inertial mass 30 is mounted, and a pair of supporting arms 29d and 29e for rotatably supporting the actuator 31.

The inertial mass 30 comprises a leg portion 30a, a mass portion 30b formed on the leg portion 30a, and an operating portion 30c for operating the actuator 31. The inertial mass 30 mounted on the mass mounting portion 29c is standing in upright posture as shown in the figure in the normal state, and tilts in the direction α when the speed reduction more than the prescribed value is applied to the vehicle, so that the operating portion 30c rotates the actuator 31.

In addition, the actuator 31 comprises an axle portion 31a to be rotatably fitted into holes formed on a pair of supporting arm portions 29d and 29e of the sensor case 29, a pressed portion 31b to be pressed by the operating portion 30c of the inertial mass 30, and a stop claw 31c provided on the opposite side of the axle portion 31a and engageable with the external teeth 21b of the lock gear 21. When the inertial mass

30 is in the upright posture, the actuator 31 is in the lowest position that is a non-engaged position in which the stop claw 31c does not engage with the external teeth 21b, and when the inertial mass 30 tilts in the direction α, it rotates upwardly so as to assume the engaged position in which the stop claw 31c is engaged with the external teeth 21b.

As shown in Fig. 2, the motor 10 can be mounted on the second retainer 35 that can be mounted to the left sidewall 15 of the frame 2. The second retainer 35 is provided with a thorough hole 35a through which the axle 10a of the motor 10 passes. The operation of the motor 10 is controlled by the CPU described above according to various information including information on the vehicle's traveling state such as the speed of the vehicle or the acceleration of the vehicle, or to information on the vehicle's operating state such as the speed of depression of the brake pedal or the speed of depression of the acceleration pedal.

The power transmission gear mechanism 11 comprises a motor gear 36 formed in a helical gear mounted to the axle 10a of the motor so as to rotate as a single piece, and a connect gear 37 consisting of a large diameter connect gear 37a formed in a helical gear being always engaged with the motor gear 36, and a small diameter connect gear 37b formed concentrically and unitarily with and is smaller in diameter than the large diameter connect gear 37a.

As shown in Fig. 1 and Fig. 4, the speed reducing mechanism 12 comprises a first carrier 38 formed of an annular disk, two planetary gears 38 and 40, two idle gears 41 and 42, a sun gear 43, a ring-shaped internal gear 44, and a speed reducing gear 45.

The first carrier 38 is provided with a regular hexagonal through hole 38a in the center thereof, and four supporting holes 38b, 38c, 38d and 38e formed at a regular intervals in the peripheral direction.

The planetary gear 39 and 40 comprises large planetary gears 39a and 40a both having large diameters respectively, and small planetary gears 39b, 40b both having smaller diameters

than the large planetary gears 39a and 40a. The large planetary gears 30a and 40a and small planetary gear 39b and 40b are formed unitarily and concentrically, and the small planetary gears 39b and 40b have the same dimensions as the idle gears 41, 42. The planetary gears 39 and 40 are respectively supported in two diametrically opposed supporting holes 38b and 38d formed on the first carrier 38 so as to rotate with respect to each other. In Fig. 1, small planetary gears 39b and 40b are not clearly shown.

The idle gears 41 and 42 are supported in two other diametrically opposed supporting holes 38c and 38e formed on the first carrier 38 so as to rotate with respect to each other.

The sun gear 43 is supported by the first shaft portion 26f of the torsion bar 26 so as to rotate with respect to each other.

The internal gear 44 has internal teeth 44a on the inner periphery and ratchet teeth 44b on the outer periphery. In addition, the speed reducing gear 45 has internal teeth 45a on the inner periphery, and external teeth 45b on the outer periphery.

The large planetary gears 39a and 40a of two planetary gears 39 and 40 are respectively engaged with the sun gear all the time and the small planetary gears 39b and 40b are engaged with the internal teeth 44a of the internal gear 44 all the time. Two idle gears 41 and 42 are engaged with the internal teeth 44a of the internal gear 44. In addition, the internal teeth 45a of the speed reducing gear 45 are engaged with the sun gear 43 all the time, and the external teeth 45b of the speed reducing gear 45 are engaged with the small diameter connect gear 37b of the connect gear 37.

As shown in Fig. 1 and Fig. 2, the power transmission path switching mechanism 13 comprises a switchgear 46, a plunger 47, a spring 48, and a stop lever 49. As shown in Fig. 7(a) to (d), the switchgear 46 is supported by the supporting shaft 50 mounted into the mounting hole 35b of the second retainer 35 so as to rotate and move in the axial direction by a prescribed distance, and composed of a gear portion 46a

formed in a helical gear and an inclined surface 46b in the shape of a truncated cone. The plunger 47 is slidably mounted to the cylinder housing 51 mounted on the second retainer 35. In this case, the rotation of the plunger about the elongated axis is prevented by the projecting wall 47a axially extending on the plunger 47 slidably fitted into the elongated guide groove 51 on the cylinder housing 51.

The plunger 47 is provided on the tip thereof with a contact portion 47c having an inclined surface 47b of the same inclination as the inclined surface 46b in the shape of the truncated cone. A spring 48 is compressively mounted between the plunger 47 and the cylinder housing 51, and the spring force of the spring 48 urges the plunger 47 toward the switchgear 46 all the time and brings the contact portion 47c into contact with the switchgear all the time. In this case, when the motor 10 is not in operation, as shown in Fig. 7(b), the switchgear 46 is placed to the rightmost position of the figure, and simultaneously the plunger 47 projects to the outermost position so that the front surface of the inclined surface 47b of the contacting portion 47c comes in contact with the front surface of the inclined surface 46b of the switchgear 46. These inclined surface 46b and the inclined surface 47b define the cam mechanism in which the plunger 47 is moved in accordance with the axial movement of the switchgear 46.

When the motor 10 is in operation, as shown in Fig. 7(d), the switchgear 46 moves to the left and is placed to the leftmost position of the figure, and simultaneously the plunger 47 is retracted to the innermost position so that the tip of the contact portion 47c comes into contact with the outer periphery of the gear portion 46a of the switchgear. In this state, the tip of the contacting portion 47c is not engaged with the teeth of the gear portion 46a of the switchgear 46. The actions of the switchgear 46 and the plunger 47 from the state shown in Fig. 7(b) to the state shown in Fig. 7(d) and vice versa will be described later.

The plunger 47 is provided with a stop lever operating portion 47d.

The stop lever 49 comprises an axle 49a, a bifurcated operating lever portion 49b, and a stop claw 49c. The axle 49a is rotatably supported by the second retainer 35. The branch portion of the operating lever portion 49b is engaged with the stop lever actuating portion 47d of the plunger 47, and the plunger 47 allows the stop lever 49 to rotate about the axle 49a. In addition, the stop claw 49c engages with and released from the ratchet teeth 44b of the internal gear 44. When the plunger 47 is in the state shown in Fig. 7(b), the stop claw 49c is placed to the position in which the stop claw 49c is not engaged with the ratchet teeth 44b as shown in Fig. 8, and when the plunger 47 is in the state shown in Fig. 7(d), the stop claw 49c is placed to the position engageable with the ratchet teeth 44b as shown in Fig. 9.

In the power transmission path switching mechanism 13 in such an arrangement, when the motor 10 is not in operation, the power transmission path between the reel 4 and the motor 10 comprising the power transmission gear mechanism 11 and the speed reducing mechanism 12 is set to the OFF-state in which the reel 4 and the motor are rotationally free with respect to each other, and when the motor 10 is in operation, it is set to the ON-state in which the reel 4 and the motor 10 are rotationally connected.

As shown in Fig. 1 and Fig. 4, spring means 14 comprises a second cover 52, a bush 53, a return spring 54, and a spring cover 55. The second cover 52 is mounted to the second retainer 52 so as to cover the power transmission gear mechanism 11, a speed reducing mechanism 12, and a power transmission path switching mechanism 13. An annular projection 52a is provided on the second cover 52 on the opposite side of the speed reducing mechanism 12, and a return spring 54 is received within the annular projection 52a. In addition, a spring mounting portion 52b is provided within the annular projection 52a, and the second cover 52 is formed with a supporting hole 52c for rotatably supporting the first shaft portion 26f of the torsion bar 26 via a bush 53.

The bush 53 comprises a bearing portion 53a and a spring

mounting portion 53b. The bush 53 is fitted by means of a spline into the spline groove 26e formed on the tip of the torsion bar 26 so as to rotate with a torsion bar 26 as a single piece. In this case, the bearing portion 53a of the bush 53 is rotatably supported within the supporting hole 53c formed on the second cover 52, and supports the first shaft portion 26f of the torsion bar 26.

A return spring 54 is formed in a flat spiral spring, and the end of the outer periphery thereof is connected to the spring mounting portion 52b of the second cover 52 and the end of the inner periphery 54b thereof is connected to the spring mounting portion 53b of the bush 53. The spring force of the return spring 54 urges the reel 4 in the belt winding direction CCW via the bush 53 and the torsion bar 26 all the time.

As shown in Fig. 2 and Fig. 6, the second carrier 56 comprises a cylindrical first shaft portion 56a of regular hexagonal cross section, and a cylindrical second shaft portion 56b (shown only in Fig. 6) being regular hexagonal in cross section of outer periphery and circular in cross section of inner periphery.

The end of the through hole 4d of the reel 4 on the side of the sidewall 15 is fitted on the outer periphery of the first shaft portion 56a so as not to rotate with respect to each other, and the second torque transmitting portion 26d of the torsion bar 26 is fitted into the inner periphery of the first shaft portion 56a so as not to rotate with respect to each other, so that the reel 4, the second carrier 56, and the second torque transmitting portion 26d of the torsion bar 26 rotate as a single piece. On the other hand, the through hole 38a of the first carrier 38 is fitted on the outer periphery of the second shaft portion 56n so as not to rotate with respect to each other, and the first shaft portion 26f of the torsion bar 26 is fitted to the inner periphery of the second shaft portion 56b, so that the first and second carrier 38, 56 rotate as a single piece.

The second carrier 56 is axially fixed with respect to

the second torque transmitting portion 26d by means of an E-ring 57 mounted on the first shaft portion 26f of the torsion bar 26. The belt tension control mechanism for controlling the tension of the seat belt 3 is composed of a motor 10, a power transmission gear mechanism 11, a speed reducing mechanism 12, a power transmission path switching mechanism 13, and a CPU.

The operation of the belt tension control mechanism in such an arrangement will now be described.

(1) Non-operating mode of the seat belt retractor (the state in which the seat belt is stored)

When the seat belt retractor 1 is in non-operating mode, the seat belt 3 is wound on the reel 3 by spring means 14. The motor 10 is also in non-operating mode. In this non-operating mode, as shown in Fig. 8, the motor gear 36, a connect gear 37, and switchgear 46 do not rotate and, therefore, the switchgear 46 is placed to the position shown in Figs. 7(a) and (b), and simultaneously the plunger 47 project to the outermost position so that the front surface of the inclined surface 47b of the contacting portion 47c comes into contact with the front surface of the inclined surface 46b of the switchgear 46. In this state, the stop lever 49 is placed to the position in which the stop claw 49c is not engaged with the ratchet teeth 44b of the internal gear 44, and the power transmission path is set to the OFF-state. Therefore, the internal gear 44 is free to rotate in any of the belt unwinding direction CW and the belt winding direction CCW, and thus the belt tension control mechanism is in non-operating mode.

(2) Seat belt unwinding operation

When the seat belt is unwound from the non-operating mode of the seat belt retractor 1 as atated above, the reel rotates in the belt unwinding direction CW. Then, both the second torque transmitting portion 26d of the torsion bar 26 and the second carrier 56 shown in Fig. 6 rotates in the belt unwinding direction CW. Since the first carrier 38 rotates in the same direction CW, the planetary gears 39 and 40 tend to rotate respectively around the sun gear 43 in the same direction CW. Therefore, the large planetary gears 39a and 40a of the planetary gears 39 and 40 tend to rotate respectively in the

belt unwinding direction CW so as to rotate the sun gear 43 in the belt winding direction CCW, and on the other hand, the small planetary gears 30b and 40b tend to rotate in the belt-winding direction CCW so as to rotate the internal gear 44 in the belt unwinding direction CW. In this state, since the sun gear 43 is engaged with the speed reducing gear 45 all the time, the speed reducing gear 45 is engaged with the small connect gear 37b of the connect gear 37 all the time, and the large diameter connect gear 37a integrated with the small diameter connect gear 37b is engaged with the motor gear 36 and the switchgear 46 all the time, a prescribed rotational resistance is applied to the sun gear 43, while the internal gear 44 rotates freely as atated above. In other words, the internal gear 44 rotates freely and the sun gear 43 does not rotate. In this state, the small planetary gears 39b and 40b rotate with respective large planetary gears 39a and 40a in the belt unwinding direction CW.

Since the sun gear 43 does not rotate, the rotation of the reel 4 in the belt unwinding direction CW during unwinding operation of the seat belt 3 is not transmitted to the switchgear 46, and thus the power transmission path switching mechanism 13 is not actuated, the power transmission path between the reel 4 and the motor 10 remains in OFF state, the rotation of the reel 4 is not transmitted to the motor 10, and thus the motor is not affected by the rotation of the reel 4. At this time, since the motor 10 is not driven, the belt tension control mechanism remains in the non-operating mode.

When the belt is being unwound, the rotation of the second torque transmitting portion 26d winds up the return spring 54 of the spring means, thereby increasing the spring force with the unwound amount of the belt.

(3) Winding operation of the seat belt by motor driving torque

Referring now to Fig. 8, when the motor 10 is driven to rotate the reel 4 in the belt winding direction CCW, the motor gear 36 rotates in the belt winding direction CCW, and the connect gear 37 rotates in the belt unwinding direction CW with its speed reduced. Then the speed reducing gear 45 rotates with the speed further reduced in the belt winding direction

CCW, thereby rotating the sun gear 43 in the same direction CCW at the same speed as the speed reducing gear 45. The rotation of the sun gear 43 rotates the planetary gears 39 and 40 about its axis with the speed further reduced in the belt unwinding direction CW, thereby rotating the internal gear 44 in the same direction CW. At this time, since the internal gear 44 rotates, the planetary gears 39 and 40 do not rotate around the sun gear 43.

On the other hand, when the connect gear 37 rotates, the switchgear 46 rotates in the belt winding direction CCW at the same time. In this case, since the large diameter connect gear 37a of the connect gear 37 and the switchgear 46 are engaged by helical engagement, the switchgear is subjected to a thrust force in the direction of axis. Then, the switchgear 46 is moved axially by this thrust force and placed to the leftmost position shown in Fig. 7(d). Concurrently, the inclined surface 47b of the contacting portion 47c of the plunger 47 slides along the inclined surface 46b of the switchgear 46 with the axial movement of the switchgear 46, and the plunger 47 moves away from the switchgear 46 and retracted into the cylinder housing 51.

Since the switchgear 46 is supported by the second retainer 35 in the thrusting direction after all, the switchgear 46 stops its axial movement and is placed in the leftmost position as shown in Fig. 7(d). In this state, as atated above, the plunger 47 is retracted into the cylinder housing to the innermost position so that the tip of the contacting portion 47c contacts the outer periphery of the gear portion 46a of the switchgear 46. By this retracting action of the plunger 47, as shown in Fig. 9, the stop lever actuating portion 47d presses the operating lever portion 49b of the stop lever 49, thereby rotating the stop lever 49 about the axle 49a as is descried above, so that the stop claw 49c is placed at the position in which it can engage with the ratchet teeth 44b.

Then, by the rotation of the internal gear 44 in the belt unwinding direction CW, the ratchet teeth 44b and the stop claw 49c are engaged with respect to each other and the rotation of

the internal gear 44 stops. In this way, when the motor 10 is actuated, the stop lever 49 is actuated quickly and the rotation of the internal gear 44 in the belt unwinding direction CW is prevented, and the power transmission path between the reel 4 and the motor 10 is set to the ON-state. In other words, the belt tension mechanism is set to the operating mode.

Accordingly, as atated above, since the planetary gears 39 and 40 rotate on their axes by the driving torque of the motor 10, when the internal gear 44 stops rotating, the planetary gears 39 and 40 rotate around the sun gear 43 along the internal teeth 44a of the internal gear 44 in the belt winding direction CCW with the speed reduced. Therefore, the first and second carriers 38 and 58 rotate in the belt winding direction CCW at the speed of the planetary gears 39 and 40 rotating around the sun gear 43, and the reel 4 rotates in the belt-winding direction CCW. In this manner, the reel 4 is rotated by the rotation of the motor 10 that is transmitted after being reduced in speed at a prescribed speed reduction ratio by the speed reducing mechanism 12.

The rotation of the reel 4 in the belt winding direction CCW force the seat belt 3 to be wound up onto the reel 4 by a rotational torque of the motor 10, and thus the belt tension is controlled. The CPU controls the motor 10 according to various information including information on the vehicle's traveling state such as the speed of the vehicle or the acceleration of the vehicle, or to the vehicle's operating state such the speed of depression of the brake pedal or the speed of depression of the accelerating pedal to control the winding amount of the seat belt 3, so that the belt tension is controlled to the desired value.

In this case, since the spring 54 is unwound by the rotation of the second carrier 56 in the belt winding direction CCW, the spring force of the return spring 54 is weakened.

(4) Action to release the seat belt forced-winding operation

In the seat belt forced-winding operation as is described in (3) above, when the motor is driven in the opposite

direction of the one described in (3), that is, in the belt unwinding direction CW, the reel 4 rotates in the belt unwinding direction CW via gears 36, 37, 45, 43, 39, and 40, and the first and the second carriers 38 and 56, thereby loosening the forced-wound seat belt 3. Though the switchgear 46 is rotated in reverse by the rotation of the connect gear 37, the switchgear 46 is subjected to a thrust force in the direction reverse of the rotation described in (3) by the large connect gear 37a since the large connect gear 37a and the switchgear 46 is engaged by helical engagement. Then the switchgear 46 moves from the state shown in Fig. 7(d) to the right. When the upper end of the inclined surface 46b of the switchgear 46 passed the lower end position of the inclined surface 47b of the plunger 47 by the movement of the switchgear 46, the inclined surface 47b of the plunger 47 comes into contact with the inclined surface 46b by a spring force of the spring 48 and the plunger comes out with the inclined surface 47b kept in contact with the inclined surface 46b. By this projecting action of the plunger 47, the stop lever actuating portion 47d of the plunger 47 rotates the stop lever 49 to the non-operation position.

As a final stage, the switchgear 46 and the plunger 47 assume the non-operating mode as shown in Fig. 7(b). In this non-operating mode, the stop lever 49 is placed in the non-operating position, and placed to the non-engaging position in which the stop claw 49c is not engaged with the ratchet teeth 44b of the internal gear 44. Consequently, the internal gear 44 is free to rotate and the reel 4 and the motor 10 are rotationally free with respect to each other.

In the seat belt retractor 1 of this example, the tension of the seat belt 3 is controlled by a rotational torque of the motor 10 in the belt tension mechanism controlled by the CPU according to the state of the passenger in the vehicle, the operating mode outside the vehicle, or the operating condition of the seat belt 3.

Though the locking means 5, lock-actuating mechanism 6, the EA mechanism 7, and the speed reduction detecting means 8 of this example act exactly in the same manner as those in

conventional use, a brief explanation will be given.

In the case where a prescribed speed reduction acts on the vehicle with the seat belt worn by the passenger, the inertial mass 30 of the speed reduction detecting means 8 tilts forward to rotate the actuator 31 to the position in which the stop claw 31c engages the external teeth 21b of the lock gear 21. By a speed reduction of the vehicle, the seat belt 3 tends to be drawn out by the forward inertia of the passenger. Then the reel 4, the torsion bar 26, the locking base 19 and the lock gear 21 tend to rotate together in the belt unwinding direction CW. However, since the rotation of the lock gear 21 of the lock actuating mechanism 6 in the belt unwinding direction CW is prevented by engagement between the stop claw 31c and the external teeth 21b, only the reel 4, the torsion bar 26, and the locking base 19 rotate in the same direction CW. Therefore, there is generated a rotational differential (relative rotation) between the locking base 19 and the lock gear 21, the pawl 20 of the locking means 5 rotates, and thus the stop claw 20b of the pawl 20 is engaged with the internal teeth 18a of the internal teeth member 18 on the frame 2. Consequently, the rotation of the reel 4 in the belt unwinding direction CW stops to prevent the seat belt 3 from being unwound, and thus the inertial movement of the passenger may be prevented.

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The inertia of the passenger increases with the increase in the speed reduction of the vehicle. In such a case, the torsion bar is twisted between the first and the second torque transmitting portions 26b and 26d to generate a rotational differential (relative rotation) between the reel 4 and the locking base 19, thereby rotating only the reel 4 by a prescribed amount in the belt unwinding direction CW. The twist of the torsion bar 26 actuates the EA mechanism 7 to alleviate the impact applied to the passenger by the seat belt 3. At this time, since a rotational torque of the reel 4 generated by the rotation of the reel 4 acts upon the second torque transmitting portion 27d to rotate the stop 27 with respect to the locking base 19, the stop 27 moves axially toward the disk portion 19a of the locking base 19, but not as

far as the position in which the side surface of the stop 27 comes into contact with the disk portion 19a. When the speed of the vehicle significantly increases, the inertia of the passenger significantly increases as well. In such a case, since the rotational differential between the reel 4 and the locking base 19 is significantly large, the stop 27 moves significantly in the direction of the axis due to the increased amount of rotation thereof, and thus the side surface of the stop 27 comes into contact with the disc portion 19a. Then the relative rotation of the stop 27 and the locking base 19 is prevented, and the stop 27 and the locking base 19 rotate as a single piece, and therefore, the reel 4 and the locking base 19 rotate as a single piece, and the EA effect (impact alleviating effect) of the EA mechanism 7 terminates.

Irrespective of whether the seat belt is worn or not, when the seat belt is unwound in the normal speed, the reel 4, the torsion bar 26, the locking base 19, and the lock gear 21 rotate together in the belt unwinding direction CW as atated above. In such a case, the flywheel 22 rotates together with the lock gear 21, and the lock gear 21 does not rotate with respect to the flywheel 22. In the case where the seat belt 3 is abruptly unwound at the speed higher than the normal speed, the reel 4, the torsion bar 26, the locking base 19 and the lock gear 21 rotate together, but more abruptly than the normal case. Then the flywheel 22 experiences a delay in the rotation, and rotates with respect to the lock gear 21. Therefore, the stop claw 22c of the flywheel 22 comes to the position to engage the internal teeth 24e of the retainer 24, and the further rotation of the lock gear 21 allow the stop claw 22c to engage with the internal teeth 24e of the retainer 24, and the further rotation of the lock gear 21 in the belt unwinding direction CW is prevented. When the rotation of the lock gear 21 in the belt unwinding direction CW is prevented, the rotation of the reel 4 in the belt unwinding direction CW is also prevented as in the case of the abrupt speed reduction described above. In this way, the abrupt unwinding of the seat belt 3 is prevented.

As is described thus far, in the seat belt retractor 1 of

the first example, the control of the tension of the seat belt 3 may be carried out reliably and easily by a rotational torque by controlling the rotation of the reel 4 of the motor via the power transmission gear mechanism 11 and the speed reducing mechanism 12

In addition, since the ON and OFF-states of the power transmission path between the reel 4 and the motor 10 is controlled by the power transmission path switching mechanism 13 that is operated by a rotational torque of the motor 10, it is not necessary to use a specifically designed actuator using other motive power such as a electromagnetic solenoid or the like for actuating the power transmission path switching mechanism 13. Therefore, the number of the components of the power transmission path switching mechanism may be reduced, thereby simplifying the structure thereof, and further reducing the cost.

Fig. 10 is an exploded perspective view showing the seat belt retractor according to another example of the embodiments of the invention, Fig. 11 to Fig. 13 are partly enlarged exploded perspective views, Fig. 14 is a partly broken side view of a motor, a power transmission gear mechanism, a speed reducing mechanism, and a power transmission path switching mechanism used in the seat belt retractor shown in Fig. 10 in the non-operating mode, Fig. 15 is a side view as in Fig. 14 showing the state in which the seat belt is wound by a driving force of the motor, and Fig. 16 is a side view as in Fig. 14 showing the state in which the winding operation of the seat belt is released. In the description about the following examples, like reference numerals are used for the identical components to those shown in the previous example, and the detailed description is omitted. Out of the construction, operation, and effects of the seat belt retractor of this embodiment, only the parts different from the previous example will be described and the description of the parts identical to those of the previous example will be omitted.

While the motor 10 is mounted in the lower portion of the retractor 1 in the first example described above, the motor 10

of the seat belt retractor 1 of the second example is mounted on the upper part of the retractor 1.

While, the small diameter connect gear 37b of the connect gear 37 directly engages with the external teeth 45b of the speed reducing gear 45 all the time in the power transmission mechanism 11 and the speed reducing mechanism 12 of the first example, an intermediate speed reducing gear 58 comprising a large diameter intermediate speed reducing gear 58a and a small diameter intermediate speed reducing gear 58b formed as a single piece is placed between the connect gear 37 and the speed reducing gear 45 in the power transmission mechanism 11 and the speed reducing mechanism 11 of the second example. In other words, the small diameter connect gear 37b of the connect gear 37 is engaged with the large diameter intermediate speed reducing gear 58a of the intermediate speed reducing gear 58 all the time, and the small diameter intermediate speed reducing gear 58b of the intermediate speed reducing gear 58 is engaged with the external teeth 45b of the speed reducing gear 45 al the time, so that the rotational speed of the connect gear 37 is reduced via the intermediate speed reducing gear 58 and transmitted to the speed reducing gear 45. It is possible to provide the adequate number (one or more) of intermediate gears between the connect gear 37 and the speed reducing gear 45 depending on the position of the motor 10, otherwise the intermediate gear may be omitted.

As shown in Fig. 10 and Fig. 11, in the second example, the first carrier 38 is provided with three planetary gears 39, 40, and 59 so as to rotate about their own axes. In such a case, these planetary gears 39, 40, and 59 are mounted to the first carrier 38 by reduction pins 61, 62, and 63 via a reduction plate 60. While the planetary gears 39 and 40 comprises a large and a small planetary gears having two different diameters respectively in the first example described above, in other words, large planetary gears 39a and 40a being engaged with the sun gear 43 all the time, and small planetary gears 39b and 40b being engaged with the internal teeth 44a of the internal gear 44 all the time, the planetary gears 39, 40, and 59 of the second example are formed of planetary gears

having the same diameters with respect to each other, and the planetary gears being the same in diameter are engaged with both of the sun gear 43 and the internal teeth 44a of the internal gear 44 all the time.

The number of the planetary gears is not limited to three, but it may be two as in the first example, and may be four as in the third example that will be described later. In other word, the number of the planetary gears provided may be any suitable number but at least one. The adequate number of the idle gears such as the idle gears 41 and 42 in the first example may be provided as well. The speed reducing plate 60 may be omitted as in the first example. In addition, the planetary gears 39, 40, and 50 of the second example may be composed of a large and a small planetary gears having two different diameters as in the first example.

While the power transmission path switching mechanism 13 of the first example comprises a switchgear 46, a plunger 47, a spring 48, a stop lever 49, a supporting shaft 50, and a cylinder housing 51, the power transmission path switching mechanism 13 of the second example comprises, as shown in Fig. 10 and Fig. 12, a stop lever 49, a spring-holding member 64 unitarily and coaxially assembled to the connect gear 37 that is rotatably supported by the retainer so as to rotate with the connect gear 37 as a single piece, and a lever spring (corresponding to the control lever of the invention) 65 having a prescribed resiliency unitarily assembled to the spring-holding member 64 on one end so as to rotate with the spring-holding member 64 as a single piece and connected to the stop lever 49 on the other end.

In this case, on the axial side surface of the spring-holding member 64, there are provided three projecting pins 64a axially extending therefrom, and the spring-holding member 64 is assembled to the connect gear 37 by fitting these projecting pins 64a into three axial hole 37c formed on the connect gear 37 respectively. On the outer periphery of the spring-holding member 64, there are provided three projections 64b radially extending therefrom at regular intervals in the peripheral

direction (three projections 64b are shown in Fig. 14). The lever spring 65 is assembled to the spring-holding member 64 by disposing the bent portion 65a of the lever spring 65 around the outer periphery of the spring-holding member 64, and fitting the same between the two projections 64b of the spring-holding member 64 and the connector gear 37 with prescribed friction in the direction of rotation.

The stop lever 49 is provided on the second retainer 35 so as to be brought into and out of contact with the ratchet teeth 44b of the internal gear 44 by parallel movement.

When the connect gear 37 rotates counter-clockwise in Fig. 15 (in other words, the belt winding direction CCW) from the non-operating mode shown in Fig. 14, the rotation of the connect gear 37 in the belt winding direction CCW is transmitted to the lever spring 65 via the spring-holding member 64 to rotate the lever spring 65 in the same direction, and the rotation of the lever spring 65 causes a parallel movement of the stop lever 49 toward the internal gear 44, so that the stop claw 49c is placed to the position in which it can engage the ratchet teeth 44b of the internal gear 44. The clockwise rotation of the connect gear 37 in Fig. 16 (in other words, the rotation in the belt unwinding direction CW) transmitted from the state shown in Fig. 15 via the spring-holding member 64 and the lever spring 65 to the stop lever 49 causes a parallel movement of the stop lever 49 away from the internal gear 44, so that the stop claw 49c is placed to the position in which it cannot engage with the ratchet teeth 44b.

In the retractor 1 of the second example, as shown in Fig. 10, the locking base 19 is provided on one end of the torsion bar portion 26a of the torsion bar 26 unitarily with the torsion bar 26. Therefore, in the second example, the first torque transmitting portion 26b of the torsion bar portion 26a is not provided as in the first example. It is also possible to provide the torsion bar portion 26a and the locking base 19 as separate pieces, so that the torsion bar portion 26a and the locking base 19 rotate as a single piece via the first torque transmitting portion 26b provided on the torsion bar portion 26a as in the first example.

In addition, a cylindrical stop 27 of the EA mechanism 7 and the male screw 19b formed on the locking base 19 to be engaged with the female screw 27a of the stop 27 as in the first example are not provided in the second example. Therefore, the reel 4 and the locking base 19 rotates with respective to each other but not as a single piece as a result of twisting action of the torsion bar 26.

In the second example, the torsion bar 26 is not provided with the first shaft portion 26f that is provided on the distal side of the second torque transmitting portion 26d in the first example, and the reel 4 is not axially cut through as in the first example. In addition, in the second example, the second carrier 56 described in the previous example is not provided. Therefore, the second torque transmitting portion 26d of the torsion bar 26 is directly fitted to the through hole 4d of the reel 4 from the end on the side of the side wall 15 so as not to rotate with respect to each other, and axial engagement between the supporting pin 66 radially inserted into the reel 4 and the side portion of the second torque transmitting portion 26d prevents the torsion bar 26 from coming off in the axial direction. Because the supporting pin 66 is provided, the E-ring 57 described in the first example is not provided.

Though the torsion bar 26 is not provided with the first shaft portion 26f as in the first example, the reel 4 of the second example is provided with the first shaft portion 4e, the second shaft portion 4f having a diameter smaller than that of the first shaft portion 4e, and the third shaft portion 4g having a diameter smaller than that of the second shaft portion 4f aligning in this order so as to extend its length toward the tip.

The first shaft portion 4e is provided with the first carrier 38 fitted thereto by means of a spline so as to rotate with the first shaft portion 4e as a single piece (in other words, to rotate with the reel 4 as a single piece), and the sun gear 43 is supported thereon so as to rotate with respect to each other. The sun gear 43 is engaged with the internal

teeth 45a of the speed reducing gear 45 all the time as in the first example. The second shaft portion 4f is connected with the output shaft of the pretensioner cassette 67, not shown, and the bearing 68 both fitted by means of splines so as to rotate with the second shaft portion 4f as a single piece (in other words, so as to rotate with the reel 4 as a single piece), and the second shaft portion 4f is rotatably supported in the axial hole 67 of the housing 67a of the pretensioner cassette 67 by means of the bearing 68. The pretensioner cassette 67 comprises a pretensioner accommodated within a housing 67a. Since the pretensioner is known in the art, and is not directly related to the invention, the detailed description is omitted. However, to be brief, the pretensioner is a device that is actuated in case of an emergency such as a collision of the vehicle and winds a prescribed amount of the seat belt 3 by rotating the reel 4 in the seat belt winding direction CCW to apply a prescribed pretension to the seat belt in advance. The seat belt retractor 1 of the second example comprises a pretensioner cassette 67, however, it is needless to say that the invention is also appicable to the seat belt retractor 1 having no pretensioner. The third shaft portion 4g is fitted with a bush 53 of the spring means 14, which is not shown in the figure, so as to rotate as a single piece as in the first example.

In the second example as well, the motor is controlled by the CPU according to various information including information on the vehicle's traveling state such as the speed of the vehicle and the acceleration of the vehicle, or to information on the vehicle's operating state such as the speed of depression of the brake pedal or the speed of depression of the accelerating pedal.

Other structures of the seat belt retractor of the second example, that is, the pawl 20, the lock gear 21 in the lock actuating mechanism 6, the flywheel 22, the flywheel spring 23, the housing 28 in the speed reduction detecting means 8, the sensor case 29, the inertia mass 30, the actuator 31, the first cover 34, the second cover 52 of the spring means 14, the bush 53, the return spring 54, and the spring cover 55 are identical to the first example.

The operation of the belt tension control mechanism in such an arrangement will now be described.

(1) Non-operating mode of the seat belt retractor (the state in which the seat belt is stored)

When the seat belt retractor 1 is in non-operating mode, the seat belt 3 is wound on the reel 3 by spring means 14. The motor 10 is also in non-operating mode. In this non-operating mode, since the motor gear 56 and the connect gear 37 do not rotate, as shown in Fig. 14, the stop lever 47 is placed to the non-operating position in which the stop claw 49c is not engaged with the ratchet teeth 44b of the internal gear 44, and the power transmitting path is set to the OFF-state. Therefore, the internal gear 44 is free to rotate in either of the belt-unwinding direction CW and the belt-winding direction CCW, and thus the belt tension control mechanism is in non-operating condition. At this time, the power transmission path extending through the motor gear 36, the connect gear 37, the intermediate speed reducing gear 58, and the speed reducing gear 45 requires a force (torque) equal to or higher than a given value for rotating these gears by a torque held by the motor 10 in non-operating mode.

(2) Seat belt unwinding operation

Since the reel 4 is rotated in the belt unwinding direction CW when the seat belt 3 is unwound from the non-operating mode of the seat belt retractor as atated above, the second torque transmitting portion 26d of the torsion bar 26 rotates in the belt unwinding direction CW. Then, the first carrier 38 rotates in the same direction CW, and the planetary gears 39, 40, and 59 tend to rotate around the sun gear 43 respectively in the same direction CW. In this state, the sun gear 43 is engaged with the speed reducing gear 45 all the time, and the speed reducing gear 45 is engaged with the small diameter intermediate speed reducing gear 58b of the intermediate speed reducing gear 58 all the time, and thus a prescribed force is required to rotate the intermediate speed reducing gear 58 as atated above. Therefore, while the sun gear 43 is applied with a rotational resistance, the internal gear 45 is free to rotate as atated above. In other words, the

internal gear 45 rotates freely and the sun gear does not rotate. In this situation, all of the planetary gears 39, 40, and 59 become rotatable in the belt unwinding direction CW.

Because the sun gear does not rotate, the rotation of the reel 4 in the belt unwinding direction CW during the seat belt 3 unwinding operation is not transmitted to the connect gear 37, and thus the lever spring 65 is not actuated and the stop lever 49 does not move. Therefore, the power transmission path switching mechanism 13 is not actuated, and the power transmission path between the reel 4 and the motor 10 remains in the OFF-state, so that the rotation of the reel 4 is not transmitted to the motor 10, and the motor is not affected by the rotation of the reel 4. Since the motor 10 is not actuated in this state, the belt tension control mechanism is held in the non-operating mode.

When the belt is unwound, the rotation of the third shaft portion 4g of the reel 4 winds up the return spring 54 via the bush 53 of the spring means, and thus the spring force gradually increases according to the unwound amount of the belt.

(3) The seat belt winding operation by a motor driving torque

When the motor is actuated from the non-operating mode shown in Fig. 14 so that the reel 4 rotates in the belt winding direction, the motor gear 36 rotates clockwise (the same direction CW as the belt unwinding direction CW of the reel 4) as shown in Fig. 15, and the connect gear 37 rotates in the belt winding direction CCW with the speed reduced. Then, since the bent portion 65a of the lever spring 65 is fitted between the projection 64b of the spring-holding member 64 and the connector gear 37 with prescribed friction in the direction of rotation as is described above, the rotation of the connect gear 37 in the belt winding direction CCW allows the lever spring 65 to rotate in the same direction CCW together. Then the stop lever 49 moves in parallel toward the internal gear 44 so that the stop claw 49c assumes engaging position in which it is engageable with the ratchet teeth 44b of the internal gear 44. After the stop claw 49c comes into contact with the outer periphery of the ratchet gear 44b of the internal gear 44, the lever spring 65 cannot rotate in the direction CCW any more,

but a slip is generated between the connect gear 37 and the lever spring 65, thereby rotating the connect gear 37 with respect to the lever spring 65. As a consequent, the motor 10 continues rotating.

Simultaneously, since the rotation of the connect gear 37 is transmitted to the rotating speed reducing gear 45 via the intermediate speed reducing gear 58 with the speed reduced, and the sun gear 43 rotates in the same direction CCW at the same speed as the speed reducing gear 45. The rotation of the sun gear 43 allows the respective planetary gears 39, 40, and 59 to rotate on their respective axes of rotation in the belt unwinding direction CW with the speed further reduced, and the internal gear 44 rotates in the same direction CW. In this situation, the planetary gears 39, 40, and 50 do not rotate around the sun gear since the internal gear 44 rotates.

When the internal gear 44 rotates in the belt unwinding direction CW, the ratchet teeth 44b and the stop claw 49c engage with each other, and then the rotation of the internal gear 44 stops. In this way, when the motor 10 is actuated, the stop lever 49 is quickly actuated to prevent the rotation of the internal gear 44 in the belt unwinding direction CW, and the power transmission path between the reel 4 and the motor 10 is set to the ON-state. In other words, the belt tension mechanism is set to the operating mode.

Since the rotation of the internal gear 44 in such a manner causes the respective planetary gears 39, 40, and 59 to rotate on their axes by a driving torque of the motor as atated above, the respective planetary gears 39, 40 and 59 rotate around the sun gear 43 along the internal teeth 4a of the internal gear 44 in the belt winding direction CCW with the speed reduced. Therefore, since the first carrier 38 rotates in the belt winding direction CCW at the rotating speed of the planetary gears 39, 40, and 59 around the sun gear 43, the reel 4 rotates in the belt winding direction CCW at the same speed as the rotating speed of the first carrier 38. In this way, the reel 4 is rotated in the belt winding direction CCW by the rotation of the motor 10 in the belt unwinding direction CW

transmitted with the speed reduced by the speed reducing mechanism 12 at a prescribed speed reduction ratio.

The rotation of the reel 4 in the belt winding direction CCW forces the seat belt 3 to be wound up on the reel 4 by a rotational torque of the motor 10, and the belt tension is controlled. As previously described, the motor is controlled according to the vehicle's traveling state or the vehicle's operating state, and the winding amount of the seat belt 3 is controlled to the desirable amount, thus the belt tension is controlled to the desirable value.

In this case, since the rotation of the third shaft portion 4g in the belt winding direction CCW unwinds the return spring 54, the spring force of the return spring 54 is weakened.

(4) Releasing action of the forced winding-up operation of the seat belt

When the motor rotates in reverse to the direction described in (3) as shown in Fig. 16, in the forced winding-up operation of the seat belt as is described in (3) shown in Fig. 15, the reel 4 rotates in the belt unwinding direction CW via the gears 36, 37, 58, 45, 43, 39, 40, and 59 and the first carrier 38, and the forced-wound seat belt 3 is loosened. Since the rotation of the connect gear 37 in the belt unwinding direction CW rotates the lever spring 65 in the belt unwinding direction CW, the stop lever 49 moves away from the internal gear 44 in parallel to place the stop claw 49 at the non-engaging position in which it is not engaged with the ratchet teeth 44b of the internal gear 44. Therefore, the internal gear 44 becomes free to rotate, and the reel 4 and the motor 10 are both rotationally free with respect to each other.

The seat belt retractor 1 of the second example is constructed in such a manner that the belt tension of the seat belt 3 is controlled by a rotational torque of the motor 10 in the belt tension mechanism controlled by the CPU, according to the state of the passenger in the vehicle, the operating conditions outside the vehicle, or the operating condition of the seat belt 3.

Other aspects of the operation of the seat belt retractor

1 of the second example are the same as the first example.

According to the seat belt retractor 1 of the second example, since the power transmission path switching mechanism 13 is comprised of only three members of a spring-holding member 64, a lever spring 65, and a stop lever 49, the number of the components constituting the power transmission path switching mechanism 13 may be reduced and thus the mechanism may be simplified in comparison with the first example. Therefore, the power transmission may be carried out reliably, thereby ensuring reliable and easy control of the belt tension of the seat belt 3.

In addition, by controlling the action of the stop lever 49 by the lever spring 65 having a prescribed resiliency, the movement of the stop lever 49 may be smooth and more reliable, and the impact to the internal gear 44 of the stop lever 49 in the event of collision or the like may be alleviated.

As regards other effects of the seat belt retractor 1 of this example is the same as the one in the first example.

The power transmission path switching mechanism 13 of this example may be applied to the seat belt retractor 1 of the type as described in the first example wherein the torsion bar 26 passes through the reel 4 in the direction of axis, and also to the seat belt retractor 1 of the type of this example wherein the torsion bar 26 does not pass through the reel 4 in the direction of axis.

Fig. 17 is an exploded perspective view showing the seat belt retractor of the third example according to the embodiment of the present invention, and Fig. 18 is a side view showing only the motor and the power transmission gear mechanism used in the seat belt retractor shown in Fig. 17.

In comparison with the second example shown in Fig. 10 described above, in the third example of the seat belt retractor 1 as shown in Fig. 17 and Fig. 18, the motor 10 is located on the lower portion of the retractor as in the first example shown in Fig. 1.

In the third example, as shown in Fig. 17, four planetary

gears 39, 40, 59, and 69 are mounted on the first carrier 38 by four reduction pins 61, 62, 63, and 70 respectively so as to rotate about their own axes. More specifically, as shown in Figs. 19 (a) and (b), planetary gear mounting portions 71, 72, 73, and 74 formed with female screws 71a, 72a, 73a, and 74a respectively thereon (which correspond to the transmitted torque limiting mechanism of the invention and the supporting portion of the planetary gear of the present invention) are provided on one side surface of the first carrier 38 circumferentially at regular intervals so as to project in the direction of the axis. These planetary gear mounting portions 71, 72, 73, and 74 are constructed so that they are ruptured from the roots thereof when a shearing force equal to or exceeding the prescribed value is applied in the direction of rotation of the carrier 38, as shown in Fig. 20. As shown in Figs. 19 (b) and (c), spline grooves to which the first shaft portion 4e of the reel 4 is spline fit are formed on the other side surface of the first carrier 38.

The four reduction pins 61, 62, 63, and 70 are identical, and each of them comprises, as shown in Figs. 21 (a) to (c), a head portion 76, a male screw 77 vertically extending from the head portion 76, and a tool hole 78 for inserting a tool such as a screw driver and engaging the same in the direction of rotation for rotating the reduction pins 61, 62, 63, and 70.

The respective planetary gears 39, 40, 59, and 69 are mounted on the first carrier 38 by screwing the male screw 77 of the reduction pins 61, 62, 63, and 70 into the female screws 71a, 72a, 73a, and 74a of the first carrier 38 via the reduction plate 60. The reduction pins 61, 62, 63, and 70 may be mounted to the planetary gear mounting portions 71, 72, 73, and 74 respectively of the first carrier 38 by fixing means other than screwing such as press-fitting or swaging. In such an arrangement, screw thread cutting on the male screw 77 or female screws 71a, 72a, 73a, and 74a is not necessary, and thus machining is simplified.

The planetary gears 39, 40, 59, and 69 are identical, and engaged with both the sun gear 43 and the inner teeth 44a of the internal gear 44 all the time. It is possible to provide

the adequate number, that is, one or more of the planetary gears. It is also possible to provide the adequate number of idle gear such as the idle gears 41, 42 in the first example. In addition, the reduction plate 60 may be omitted as in the first example. The respective planetary gears 39, 40, 59, and 69 of the third example may be composed of a large planetary gear and a small planetary gear having two different diameters respectively as in the first example.

While the locking base 19 and the torsion bar 26 of the second example shown in Fig. 10 are formed as a single piece, the locking base 19 and the torsion bar 26 in the third example are formed separately as in the first example, and the first torque transmission part 26b of the torsion bar 26 is fitted into the engaging hole 19h formed at the center of the locking base 19 in such a manner that they cannot rotate with respect to each other, whereby the torsion bar 26 and the locking base 19 are rotatively connected.

The locking base 19 includes a shaft 19i projecting from the center of the surface thereof on the opposite side of the engaging hole 19h, and rotatably penetrating through the components 21 and 24. On the shaft 19i, a bush 53 to which the inner end of the return spring is connected is fitted so that they can rotate together as a single unit.

The retractor 1 of the third example has substantially the same structure as the second example except for the fact that the pretensioner cassette 67 is not provided.

In the seat belt retractor 1 of the third example having such a structure, when an abrupt deceleration is applied to the vehicle in case of an emergency such as collision, the motor 10 is actuated to wind the prescribed amount of the seat belt 3 in advance to restrain the passenger. The passenger tends to move forward by the inertia, but is prevented from being moved forward and thus protected more effectively since a force of the seat belt 3 to restrain the passenger has been increased.

In such a construction that the seat belt 3 is wound by the driving force of the motor 10 in advance in case of an emergency as is described above, since the load of the motor 10

is linked to the torsion bar 26 of the EA mechanism 7, the EA load applied on the torsion bar 26 of the EA mechanism due to the load of the motor 10 itself increases to a relatively large extent when the seat belt 3 is unwound due to the inertia of the passenger. However, in the seat belt retractor 1 of the third example, a large torque, in other words, a large shearing force of the prescribed value or more is applied in the direction of rotation to the four planetary gear mounting portions 71, 72, 73, and 74 standing on the carrier 38, whereby the four planetary gear mounting portions 71, 72, 73, and 74 are ruptured at their root portion as shown in Fig. 20. Therefore, increase in the EA load due to the load of the motor 10 itself is controlled.

Other operations and effects of the seat belt retractor 1 of the third example are the same as those of the second example described above.

Fig. 22 shows the fourth example according to the embodiment of the present invention.

In the third example shown in Fig. 17, the respective planetary gears 39, 40, 59, and 69 are mounted on the four planetary gear mounting portions 71, 72, 73, and 74 respectively by the respective reduction pins 61, 62, 63, and 70 so that the respective planetary gear mounting portions 71, 72, 73, and 74 are ruptured when a sharing force of the preset value or more is applied thereon. However, in the fourth example, the planetary gear is provided with an integrated axis of rotation, which is rotatably mounted on the carrier 38 and constructed in such a manner that it is ruptured at its root when subjected to a sharing force equal to or higher than the prescribed value in the direction of rotation.

More specifically, as shown in Figs. 22 (a) and (b), the respective planetary gears 39, 40, 59, and 69 of the fourth example are composed of large planetary gears 39a, 40a, 59a, 69a and small planetary gears 39b, 40b, 59b, 69b respectively. It is needless to say that the construction of the planetary gears are not limited to this type, but the planetary gears 39, 40, 59, and 69 of the third example may be used as well. As shown in Fig. 22 (b), in the centers of the side surfaces of

the large planetary gears 39a, 49a, 59a, and 69a opposite of the small planetary gears 39b, 49b, 59b, and 69b are provided with axes of rotation 39c, 40c, 59c, and 69c (which correspond to the torque transmission limiting mechanism and the supporting portion for the planetary gear of the invention) standing upward therefrom.

As shown in Figs. 23 (a) and (b), the carrier 38 of the fourth example is formed with four through holes 79, 80, 81, and 82 circumferentially at regular intervals. Then the respective planetary gears 39, 40, 50, and 69 are rotatably mounted to the carrier 38 by fitting the axes of rotation 39c, 40c, 59c, and 69c of the respective planetary gears 39, 40, 59, and 69 into the through holes 79, 80, 81, and 82. The axes of rotation 39c, 40c, 59c, and 69c are constructed in such a manner that they are ruptured at their root portion when subjected to a sharing force equal to or higher than the preset value in the direction of rotation.

Other structure of the seat belt retractor of the fourth example is the same as those of the third example.

In the seat belt retractor 1 of the fourth example having such a structure, in case of emergency, the axes of rotation 39c, 40c, 59c, and 69c of the respective planetary gears 39, 40, 59, and 69 are subjected to a sharing force equal to or higher than the prescribed value as in the case described above, the respective axes of rotation 39c, 40c, 59c, and 69c are ruptured at the root portions thereof as shown in Fig. 24. Therefore, increase in the EA load due to the load of the motor 10 itself is controlled.

Other operations and effects of the seat belt retractor 1 of the fourth example are the same as those of the third example described above.

Fig. 25 shows the fifth example according to the embodiment of the present invention.

While the respective axes of rotation 39c, 40c, 59c, and 69c provided on the respective planetary gears 39, 40, 59, and 69 are rotatably fitted into the through holes 79, 80, 81, and 82 of the carrier 38 so that the respective axes of rotation

39c, 40c, 59c, and 69c are ruptured when subjected to a sharing force equal to or higher than the preset value in the direction of rotation in the fourth example shown in Fig. 22, the supporting pins that pass through the planetary gears and rotatably support the planetary gears are secured to the carrier so that the supporting pins are ruptured when subjected to a sharing force equal to or higher than the prescribed value in the direction of rotation in the fifth example.

More specifically, as shown in Fig. 25, the respective planetary gears 39, 40, 59, and 69 of the fifth example are composed of large planetary gears 39a, 40a, 59a, and 69a, and small planetary gears 39b, 40b, 59b, and 69b as in the case of the fourth example. It is needless to say that the construction of the planetary gears is not limited to this type, but the planetary gears 39, 40, 59, 69 of the third example may be used as well.

The centers of the respective planetary gears 39, 40, 59, and 69 of the fifth example are provided with through holes 39d, 40d, 59d, and 69d respectively. Then the supporting pins 83, 84, 85, and 86 (which correspond to the torque transmission limiting mechanism and the supporting portion for the planetary gear of the invention) having head portions 83a, 84a, 85a, and 86a are passed through these through holes 39d, 49d, 59d, and 69d, and the other ends thereof are fitted and fixed to the through holes 79, 80, 81, and 82 of the carrier 38 shown in Fig. 23. The diameters of the respective head portions 83a, 84a, 85a, and 86a are larger than the diameters of the through holes 39d, 40d, 59d, and 69d. In this way, the respective planetary gears 39, 40, 59, and 69 are prevented from being detached by the head portions 83a, 84a, 85a, 86a of the supporting pins 83, 84, 85, and 86, and these supporting pins 83, 84, 85, and 86 are constructed in such a manner that they are ruptured when subjected to a sharing force equal to or higher than the preset value in the direction of rotation.

Other structures of the seat belt retractor 1 of the fifth example are the same as those of the fourth example.

In the seat belt retractor 1 of the fifth example having

such a structure, in case of emergency, the respective supporting pins 83, 84, 85, and 86 are subjected to a sharing force equal to or higher than the prescribed value as in the case described above, the respective supporting pins 83, 84, 85, and 86 are ruptured as shown in Fig. 26. Therefore, increase in the EA load caused by the load of the motor 10 itself is controlled.

Other operations and effects of the seat belt retractor 1 of the fifth example are the same as those of the fourth example described above.

Fig. 27 is a side view showing only the motor and the power transmission gear mechanism of the sixth example according to the embodiment of the present invention, shown in the same manner as Fig. 18.

While, in the third to fifth examples described above, increase in the EA load due to the load of the motor 10 itself is controlled by discontinuing transmission of a power by rupturing the supporting portion of the planetary gears fitted to the carrier 38 when subjected to a large sharing force equal to or higher than the prescribed value in the direction of rotation, increase in the load of the motor 10 and increase in the EA load are controlled by discontinuing transmission of a power of the power transmission mechanism 12 in case of the sixth example.

More specifically, while a driving force of the motor 10 is transmitted to the speed reducing gear 45 by means of engagement between the motor gear 36 and the connect gear 37 and the intermediate speed reducing gear 58 in the third to fifth examples, power transmission between the connect gear 37 and the intermediate speed reducing gear 58 is made by the belt power transmission mechanism 87 in the seat belt retractor 1 of the sixth example.

In other words, as shown in Figs. 28 (a) and (b), the connect gear 37 is composed of a large diameter connect gear 37a and a small diameter belt pulley 37c formed coaxially and unitarily with, and having smaller diameter than, the large connect gear 37a. As shown in Figs. 29(a) and (b), the

intermediate speed reducing gear 58 is composed of a small intermediate speed reducing gear 58b and a large diameter belt pulley 58c formed coaxially and unitarily with, and having a larger diameter than, the small diameter intermediate speed reducing gear 58b. An endless belt 88 is looped between the large diameter belt pulley 58c and the small diameter belt pulley 37c, in other words, the belt power transmission mechanism 87 is composed of the small diameter belt pulley 37c, the large diameter belt pulley 58c, and the endless belt 88. These small diameter belt pulley 37c, the large diameter belt pulley 58c, and the endless belt 88 correspond to the torque transmission limiting mechanism of the invention.

The frictional coefficient between the small diameter belt pulley 37c and the endless belt 88, and the frictional coefficient between the large diameter belt pulley 58c and the endless belt 88 are set to the values such that a slip is generated between them when a torque transmitted between the respective belt pulley 37c, 58c and the endless belt 88 is equal to or higher than the prescribed value. When such a slip is generated, transmission of a power from the belt pulleys 37c, 58c to the endless belt 88, or transmission of a power from the endless belt 88 to the belt pulley 37c, 58c is discontinued, and when a torque is below the prescribed value, a power is transmitted.

The endless belt 88 may have various configurations. As an example of the configurations of the endless belt 88, as shown in Fig. 30 (a), it may be such that both of the inner and outer side surfaces 88a and 88b are smoothly formed, and the configuration of the cross-section may be a circle as shown in (a1) of the same figure, an inverted trapezoid as shown in (a2) of the same figure, a rectangle as shown in (a3) of the same figure, and inversed triangle as shown in (a4) of the same figure, otherwise it may be an oval.

As another example of the configuration of the endless belt 88, as shown in Fig. 30 (b), it may have semi-circular projections 88c, 88d on the inner and outer side surfaces 88a and 88b, and the configuration of the cross-section may be a

circle as shown in (b1) of the same figure, an inverted trapezoid as shown in (b2) of the same figure, a rectangle as shown in (b3) of the same figure, and inversed triangle as shown in (b4) of the same figure, otherwise it may be an oval. Instead of semi-circular projections 88c, 88d, rectangular projections 88c, 88c may be formed. While the projections on the inner and outer side surfaces 88c, 88d may be formed at the same position, the projections 88c, 88d may be formed alternately in a staggered arrangement on the inner and outer side surfaces 88a, 88b.

As still another example of the endless belt 88, rectangular projections 88c may formed only on the inner side surface 88a, and the configuration of the cross-section may be a circle as shown in (c1) of the same figure, an inverted trapezoid as shown in (c2) of the same figure, a rectangle as shown in (c3) of the same figure, and inversed triangle as shown in (c4) of the same figure, otherwise it may be an oval. Instead of rectangular projections 88c, semi-circular projections 88c may be formed.

As in the third example shown in Fig. 17, the large diameter connect gear 37a is engaged with the motor gear 36 all the time, and the small diameter intermediate speed reducing gear 58b is engaged with the speed reducing gear 45 all the time.

Other structures of the seat belt retractor 1 of the sixth example are the same as the third example shown in Fig. 17.

In the seat belt retractor 1 of the sixth example having such a structure, a high load is applied to the motor 10 as described above, and when the EA load at the EA mechanism 7 increases to a large extent, a torque transmitted between the respective belt pulley 37c, 58c and the endless belt 88 becomes equal to or higher than the prescribed value. Therefore, a slip is generated at least one of between the belt pulley 37c and the endless belt 88, and between the belt pulley 58c and the endless belt 88, thereby discontinuing transmission of a power between them, whereby power transmission is not taken place any more at a torque equal to or higher than the

prescribed value. Consequently, increase in the EA load due to the load of the motor 10 itself may be controlled.

In the sixth example, increase in the EA load is not controlled by rupturing the supporting portion of the planetary gear when subject to the EA lead due to the load of the motor 10 itself as in the third to fifth examples, and thus when the EA load due to the load of the motor 10 is lowered, it may be used repeatedly. Therefore, in the vehicle that can drive feely even after occurrence of an emergency such as a crush, when another emergency such as a secondary crash occurred again while the vehicle is being driven to another location such as a repair shop, the capability of the seat belt retractor to restrain the passenger by winding its seat belt by the motor may be fully exerted again.

Other operation and effects of the seat belt retractor 1 of the sixth example are the same as those of the third example described above.

While transmission of a power between the connect gear 37 and the intermediate speed reducing gear 58 is made by the belt power transmission mechanism 87 in the sixth example, transmission of a power between the motor gear 36 and the connect gear 37 may be made by the belt power transmission mechanism. Alternatively, transmission of a power between the motor gear 36 and the intermediate speed reducing gear 58 may be made by the belt transmission mechanism. In this case, an intermediate pulley comprising a large diameter pulley and a small diameter pulley corresponding to the connect gear 37 may be provided between the motor gear 36 and the intermediate speed reducing gear 58.

In the seat belt retractor 1 in the respective examples described above, the passenger is restrained by the seat belt 3 wound by the prescribed amount by the rotation of the motor 10 in the belt winding direction CCW in case of an emergency. Therefore, after the emergency state is eliminated, the seat belt 3 is restored to its original state (the state before occurrence of an emergency) by rotating the motor in the belt unwinding direction CW. In this case, the reel 4 cannot be

rotated easily in the belt unwinding direction CW because the locking means 5 is actuated and the pawl 20 is engaged with the inner teeth 18a of the internal teeth member 18 fixed on the frame 2, which resists restoration of the seat belt 3 to its original state. Therefore, the passenger is released by detaching the tongue, not shown, from the buckle.

However, it is preferable to provide the seat belt retractor that ensures restoration of the seat belt 3 to its original state only by controlling the motor 10 without detaching the tongue from the buckle every time after the elimination of the emergency state. Therefore, according to the invention, the seat belt 3 is restored more reliably to its original state by the driving power of the motor 10 after the emergency state is eliminated.

Fig. 31 shows the seventh example according to the embodiment of the present invention, wherein the seat belt 3 is restored more reliably to its original state by the driving power of the motor after the emergency state is eliminated.

The seat belt retractor 1 of the seventh example is characterized by the driving control of the motor, and any of the seat belt retractors 1 of the previous examples may be used.

In the seventh example shown in Fig. 31, the CPU is provided with vehicle's emergency state detecting means, not shown. The vehicle's emergency state detecting means measures the time period (t_2-t_1) from the time t_1 when the brake pedal reached the first fixed depressing position from the initial position, until the time t_2 when the brake pedal reached the second fixed depressing position. Then when the time described above (t_2-t_1) is equal to or below a certain value, in other words, when the driver brakes suddenly, the vehicle's emergency state detecting means determines that there is a danger of a crush to the obstacle such as a vehicle in front thereof, and outputs signals to the motor drive control means, not shown, in the CPU.

The motor drive control means restrains the passenger by rotating the motor in the belt winding direction CCW for the first preset time period T_1 according to the output signals received from the vehicle's emergency state detecting means,

and winding a prescribed amount of seat belt 3. It is possible to employ other types of vehicle's emergency state detecting means that use information on the state of operation by the driver or on the traveling state of the vehicle that may be generated when there is a danger of a crush, for example by determining whether the vehicle's deceleration is equal to or below the preset deceleration or not, as well as by determining whether the time (t_2-t_1) is equal to or below a certain time period or not as is described above.

After the motor 10 has rotated for the first preset time period T_1, the operation of the motor is stopped. In the emergency state of the vehicle, the speed reduction detecting means 8 is actuated to move the pawl 20 of the locking means 5 of the seat belt retractor 1 to the position where it is engageable with the internal teeth 18a as described above, then the seat belt is unwound by the passenger firmly restrained onto the seat of the vehicle by the driving force of the motor and the elasticity of the seat itself, and thus the reel 4 is rotated in the belt unwinding direction CW, whereby the pawl 20 is engaged with the internal gear 18a so that the rotation of the reel 4 in the belt unwinding direction CW is prevented. In other words, the locking means 5 is actuated. Therefore, the unwinding of the seat belt 3 is prevented, thereby preventing the inertial movement of the passenger effectively.

In addition, when the speed of the vehicle became zero, in other words, when the vehicle stopped, the motor 10 is driven again for the preset time period T_2 to rotate the motor in the winding direction CCW, and then the motor 10 is stopped. Driving of the motor 10 for the second preset time period T_2 in the belt winding direction CCW makes the reel 4 rotate in the belt winding direction, and thus engagement of the pawl 20 with the internal teeth 18a is released. In addition, since the vehicle is stopped and thus the speed reduction detecting means 8 is in non-operating state as it was in the initial state, the operation of the locking means 5 is released. In this state, the vehicle's emergency state is eliminated.

Subsequently, with the vehicle's emergency state eliminated, the motor 10 is rotated for the third preset time

period T_3 in the belt unwinding direction CW as is in the conventional case, and the seat belt 3 and the seat belt retractor 1 are returned to the normal state (where the normal unwinding and winding of the seat belt 3 is possible), that is, the state before the vehicle comes into the emergency state with the above described time period (t_2-t_1) equal to or below a certain time period.

As a next step, the driving control of the motor 10 of the seventh example will be described according to the flow of control shown in Fig. 32.

As shown in Fig. 32, when the vehicle's emergency state is detected according to the method described above at step S1, the motor 10 is driven and rotated in the belt winding direction CCW at the step S2. Then at the step 3, after the motor 10 is actuated, whether or not the first preset time period T_1 has elapsed is determined. When it is determined that the first preset time period T_1 has elapsed, the motor 10 is stopped at the step S4. Then at the step S5, whether or not the speed of the vehicle has become zero and the vehicle 10 has stopped is determined. When it is determined that the vehicle has stopped, the motor 10 is rotated again in the belt winding direction CCW at the step S6. Then after the motor 10 is actuated at the step 7, whether or not the second preset time period T_2 has elapsed is determined. When it is determined that the second preset time period T_2 has elapsed, the motor 10 is stopped at the step S8, and then the motor 10 is driven again and rotated in the belt unwinding direction CW. Subsequently, after the motor 10 is actuated at the step 9, whether or not the third preset time period T_3 has elapsed is determined. When it is determined that the third preset time period T_3 has elapsed, the motor 10 is stopped at the step S10.

According to the seventh example, after the locking means 5 has actuated by occurrence of the vehicle's emergency state and then the vehicle's emergency state is eliminated, the operation of the locking means 5 can be released automatically. Therefore, the passenger can be released easily and reliably from the state securely restrained by driving the motor 10 in the belt winding direction CCW. In addition, it is not

necessary to detach the engagement between the tongue and the buckle every time as in the conventional manner, so that the passenger needs not to perform cumbersome lock releasing operation.

In the example shown in Fig. 31 and Fig. 32, the motor 10 is driven intermittently for the first preset time period T_1 and for the second preset time period T_2. In this case, the motor 10 may be driven continuously until the second preset time T_2 has elapsed from the moment that the vehicle's emergency state is detected. In this case, it is not necessary to set the first preset time period T_1.

Fig. 33 is a flow chart showing the driving control of the motor shown in the eighth example according to the embodiment of the invention.

A driving control of the motor of the eighth example is also intended to restore the seat belt 3 to its original state by the driving force of the motor 10 after the elimination of the emergency state as in the case of the seventh example shown in Fig. 31 and Fig. 33 described above. In the case of the seventh example described above, the motor 10 is controlled to wind the seat belt when one of the conditions according to information on the state of operation by the driver, or to information on the vehicle's traveling state is satisfied, in other words, when the time period which takes for the brake pedal to move from the first fixed depressing position to the second fixed depressing position is equal to or below the preset fixed time period, that is, when the speed of depression of the brake pedal is equal to or higher than the preset fixed speed, or when the deceleration of the vehicle is equal to or higher than the preset fixed deceleration. However, in the eighth example, the vehicle is determined to be in the emergency state only when all of these three conditions are satisfied.

In other words, in the eighth example, it is determined to be the vehicle's emergency state when the condition that the speed of the vehicle is equal to or higher than the first preset fixed speed, the condition that the speed of depression

of the brake pedal is equal to or higher than the preset first fixed speed, and the condition that the deceleration of the vehicle is equal to the preset first fixed deceleration or higher are all satisfied, and the motor 10 is driven to wind the seat belt 3 to restrain the passenger with a relatively strong restraining force.

In the seventh example described above, after the passenger is restrained by the seat belt wound by driving the motor 10, the motor 10 is driven in the belt winding direction for the second preset time period T_2 upon stoppage of the vehicle, and then in the belt unwinding direction for the third preset time period T_3 so that the seat belt 3 is restored to the original state as it was before the vehicle's emergency state is detected. While in the eighth example, when one of several conditions is satisfied, the motor 10 is controlled in the same manner and the seat belt 3 is restored to its original state as it was before the vehicle's emergency state was detected even though the vehicle does not stop.

In other words, in the eighth example, upon detection of the vehicle's emergency state, the motor 10 is driven in the belt winding direction to wind the prescribed amount of the seat belt 3 to restrain the passenger, then after the vehicle has stopped and when one of the condition that the speed of the vehicle is equal to or lower than the preset second fixed speed, the condition that the deceleration of the vehicle is equal to or lower than the preset second fixed deceleration, and the condition that the time elapsed after the motor 10 has stopped is equal to or longer than the fourth preset time period T4 is satisfied, the motor 10 is controlled in the same manner as described above to restore its original state as it was before the vehicle's emergency state is detected.

The driving control of the motor 10 of the eighth example will now be described according to the flow shown in Fig. 33.

As shown in Fig. 33, the speed of the vehicle is detected at the step S1, and whether or not the speed of the vehicle is equal to or higher than the first fixed speed is determined at the step S2. When the speed of the vehicle is determined to be

equal to or higher than the first fixed speed, the speed of depression of the brake pedal is detected at the step S3. Detection of the speed of depression of the brake pedal may be performed in the same manner as in the case of the seventh example. At the step S4, whether or not the speed of depression of the brake pedal is equal to or higher than the fixed speed of depression is determined. When the speed of depression of the break pedal is determined to be equal to or higher than the fixed speed of depression, the deceleration of the vehicle (G) is detected at the step S5, and whether or not the deceleration of the vehicle is equal to or higher than the first fixed deceleration is determined at the step S6. When the speed of the vehicle is determined not to be equal to or higher than the first fixed speed at the step S2, or when the speed of depression of the pedal is determined not to be equal to or higher than the fixed speed of depression at the step S6, the procedure goes back to the start position and is repeated again from the step S1.

When the deceleration of the vehicle is determined to be equal to or higher than the first fixed deceleration at the step S6, it is detected to be the vehicle's emergency state, and the same procedures as the steps S2, S3, and S4 are carried out at the steps S7, S8, and S9. In other words, the motor 10 is driven in the belt winding direction at the step S7 for the first preset time period T_1 (seconds) that is determined at the step S8, then the motor 10 is stopped at the step S9 to stop the belt winding operation.

After the procedure of the step S9, three procedures are carried out simultaneously. As the first procedure, the speed of the vehicle is detected again at the step S10, and whether or not the speed of the vehicle detected is equal to or lower than the second fixed speed is determined at the step S11. As the second procedure, the deceleration of the vehicle is detected again at the step S12, and whether or not the deceleration of the vehicle is equal to or lower than the second fixed deceleration is determined at the step S13. As the third procedure, the time elapsed after the stoppage of the motor at the step S9 is counted at the step S14, and whether or

not the elapsed time counted is equal to or longer than the fourth preset time T_4 at the step 15. When the speed of the vehicle is determined not to be equal to or below the second fixed speed at the step S11, when the deceleration of the vehicle is determined not to be equal to or below the second fixed deceleration at the step S15, and when the time elapsed from the stoppage of the motor at the step S15 is determined not to be equal to or longer than the first preset time period T_4 at the step S15, the procedure goes to the step S10 to detect the speed of the vehicle, to the step S12 to detect the deceleration of the vehicle, and to the step 14 to count the elapsed time respectively.

When the speed of the vehicle is determined to be equal to or lower than the second fixed speed at the step S11, when the deceleration of the vehicle is determined to be lower than the second fixed deceleration at the step S13, or when the time elapsed from the stoppage of the vehicle is equal to or longer than the fourth preset time period T_4 at the step 15, exactly the same procedures as the steps S6, S7, S8, S9, and S10 are carried out at the steps S16, S17, S18, S19 and S20. In other words, the motor 10 is driven in the belt winding direction at the step S16 for the second preset time period T_2 (seconds) determined at the step S17 and then the motor 10 is driven in the belt unwinding direction at the step S18 for the third preset time period T_3 (seconds) determined at the step S19, and then the motor 10 is stopped at the step S20. Then, after the emergency state is eliminated, the seat belt 3 is restored to the state as it was before the vehicle's emergency state is detected.

In the eighth example, in addition to the detection of the vehicle's emergency state, the motor 10 winds the belt to restrain the passenger, and then the motor 10 winds and unwinds the seat belt 3 to restore its original state. In other words, when the crush preview signal is detected at the step S21 as shown in Fig. 33, the respective procedures from the step S7 where the passenger is restrained by the belt wound by the motor 10 to the step S20 where the operation of the motor is stopped are carried out.

In this case, a crush preview signal is generated when the distance-between-vehicles sensor detected that the distance to the car ahead is equal to or below the fixed distance at the step S22, when the slip detecting sensor detected that the wheel has slipped at the step S23, or when the vehicle action detecting sensor detected the abnormal action of the vehicle, for example, spinning of the vehicle at the step S24.

According to the motor driving control of the eighth example, the vehicle's emergency state is detected only when all of the three conditions described above are detected, thus further detail and more accurate detection of the vehicle's emergency state can be made. Since the vehicle's emergency state is detected when any one of the condition that the speed of the vehicle is equal to or below the second fixed speed, the condition that the deceleration of the vehicle is equal to or below the second fixed deceleration, and the condition that the time elapsed from the stoppage of the motor is equal to or longer than the third preset time period is satisfied, the operation of the locking means after the vehicle's emergency state is eliminated can be released automatically at the earlier stage and more flexibly in comparison with the case where restoration of the seat belt 3 after elimination of the vehicle's emergency state is made after the vehicle has stopped as in the seventh example. In addition, since the seat belt is automatically restored to the state before the vehicle's emergency state is detected after the vehicle's emergency state is eliminated and the operation of the locking means is automatically released, the passenger does no need to perform the additional lock releasing operation, and what is more, he or she can be released automatically from the restrained state.

Fig. 34 is a flow chart showing the driving control of the motor of the ninth example according to the embodiment of the invention.

While the vehicle's emergency state is detected when all the three conditions described above are satisfied in the eighth example, in the driving control of the motor of the ninth example, the speed of the vehicle is detected at the step

S1, and whether or not the speed of the vehicle detected is equal to or higher than the first fixed speed is determined at the step S2 as shown in Fig. 34. When the speed of the vehicle is determined to be equal to or higher than the first fixed speed, the motor 10 is driven in the belt winding direction at the step 7 as in the eighth example. When the speed of the vehicle is determined not to be equal to or higher than the first fixed speed, the procedure goes back to the step S1.

The speed of depression of the brake pedal is detected at the step S3, and whether or not the speed of depression of the pedal is equal to or higher than the fixed speed of depression is determined at the step S4. When the speed of depression of the pedal is determined to be equal to or higher than the fixed speed of depression, the motor 10 is driven in the belt winding direction at the step S7 as in the eighth example. When the speed of depression of the pedal is determined not to be equal to or higher than the fixed speed of depression, the procedure goes back to the step S3. The procedures of the step S3 and S4 are the same as the case of the seventh example.

At the step S5, the acceleration of the vehicle is detected. In the ninth example, the deceleration of the vehicle of each examples described above is treated as the negative acceleration of the vehicle. Therefore, when a significantly large positive acceleration of the vehicle or a significantly small negative acceleration of the vehicle (that is, deceleration of the vehicle) is detected, the vehicle is determined to be in the emergency state. Therefore, in the ninth example, the first fixed acceleration (positive value) as a reference value for comparing with the positive acceleration of the vehicle and the second fixed acceleration (negative value) as a reference value for comparing with the negative acceleration of the vehicle are set in advance. Then at the step S6, whether or not the acceleration of the vehicle is equal to or higher than the first acceleration is determined. When the acceleration of the vehicle is determined to be equal to or higher than the first fixed acceleration, the motor 10 is driven in the belt winding direction at the step S7 as in the eighth example. When the acceleration of the vehicle is

determined not to be equal to or higher than the first fixed acceleration, whether or not the acceleration of the vehicle is equal to or below the second fixed acceleration is determined at the step S6'. When the acceleration of the vehicle is determined to be equal to or below the second fixed acceleration, the motor 10 is driven to the belt winding direction at the step S7 as in the eighth example. When the acceleration of the vehicle is determined not to be equal to or below the second fixed acceleration, the procedure goes back to the step S5.

Other flows of the ninth example are the same as the case of the eighth example.

According to the ninth example, when the speed of the vehicle is high, the passenger under high speed driving is restrained and protected by winding the seat belt 3, and when there is a danger of being bumped into the back of the vehicle by another vehicle and thus the vehicle is suddenly accelerated in order to eliminate the vehicle's emergency state, the passenger under hard acceleration is restrained and protected in the same manner, and when there is a danger of crushing to another vehicle ahead and thus the vehicle is suddenly decelerated by braking suddenly in order to eliminate the vehicle's emergency state, the passenger under hard deceleration is restrained and protected in the same manner.

Other operations and effects of the ninth example are the same as the seventh and eighth examples.

In addition, it is also possible to construct the seat belt retractor of this example to detect the vehicle's emergency state when the absolute value of the acceleration of the vehicle is determined to be equal to or higher than the fixed acceleration as a reference value.

As is apparent from the description above, according to the seat belt retractor of the invention, when the motor is not in operation, the power transmission path switching mechanism is not actuated and the power transmission path is set to the OFF-state so that a rotational torque is not transmitted between the motor and the reel, and thus the rotation of the

reel during unwinding or winding operation of the seat belt is not transmitted to the power transmission path switching mechanism, and consequently the rotation of the reel may be prevented from affecting the motor and the power transmission path switching mechanism.

On the other hand, when the motor is in operation, a rotational torque of the motor actuates the power transmission path switching mechanism, and the power transmission path is set in the ON-state so that a rotational torque is transmitted between the motor and the reel, and thus a rotational torque of the motor may be transmitted to the reel via the power transmission path switching mechanism. Therefore, by rotating the reel by a rotational torque of the motor, the winding and unwinding operation of the seat belt may be carried out and thus the belt tension may be controlled. In this manner, the belt tension may be controlled easily and reliably to the desired value by operating the belt tension control mechanism by a driving force of the motor.

In this case, since the ON and OFF-states of the power transmission path are controlled by the power transmission path switching mechanism actuated by a rotational torque of the motor, it is not necessary to provide a specifically designed actuator using a special motive power such as an electromagnetic solenoid for actuating the power transmission path switching mechanism. Therefore, the number of the components used in the power transmission path switching mechanism may be reduced, and thus the structure may be simplified, thereby reducing the cost.

In addition, according to the claim 8 of the invention, since transmission of a power is discontinued by the transmitted torque limiting mechanism when a power transmission torque is equal to or higher than the prescribed value, it is possible to discontinue transmission of the power so that the load of the motor itself is not linked to the reel side in case of sudden increase of a transmitted power by occurrence of emergency state. Therefore, in the seat belt retractor having the EA mechanism on the reel side, it is possible to prevent

the load of the motor itself from being linked to the EA mechanism, thus to control increase of the EA load due to the load of the motor itself. In this case, according to claim 9 of the invention, since the supporting portion of the planetary gear is ruptured when the power transmission torque is equal to or higher than the prescribed value, the structure of the transmitted torque limiting mechanism can be simplified.

According to claim 10 of the invention, since transmission of a power is discontinued by generating a slip between the endless belt and the pulley of the transmitted torque limiting mechanism when a power transmitting torque is equal to or higher than the prescribed value, a high load of the motor itself can be prevented from being linked to the reel side by discontinuing transmission of a power even when a transmitted power is suddenly increased. Therefore, in the seatbelt retractor having the EA mechanism on the reel side, the high load of the motor itself can be prevented from being linked to the EA mechanism, as is the case of claim 8, so that increase in the EA load due to the load of the motor itself can be controlled.

In addition, the component such as a supporting portion of the planetary gear is not ruptured even when a power transmission torque is equal to or higher than the prescribed value in this construction, the component can be used repeatedly when a power transmission torque is lowered to the value below the prescribed value. Therefore, in the vehicle that can drive freely even after occurrence of an emergency such as a crush, when another emergency such as a secondary crush occurred again while the vehicle is being driven to another location such as a repair shop, the capability of the seat belt retractor to restrain the passenger by winding its seat belt by the motor may be fully exerted again.

According to claim 11 of the invention, after the locking means is actuated by occurrence of the vehicle's emergency and then the emergency state is eliminated, the actuation of the locking means is automatically released, so that the passenger is released easily and more reliably from the state of secure restraint brought by the motor being driven in the belt winding

direction. In addition, it is not necessary to release the engagement between the tongue and the buckle every time as in the case of the conventional system any more, whereby the additional lock releasing operation to be made by the passenger can be eliminated.

According to the invention as set forth in claim 12, detection of the vehicle's emergency state can be performed in further detail and more accurately by detecting the vehicle's emergency state only when all of these three conditions are satisfied.

According to the invention as set forth in claim 13, detection of the vehicle's emergency state by the vehicle's emergency state detecting means is relatively easy since the vehicle's emergency state detecting means detects that the vehicle is in the emergency state when the condition that the speed of the vehicle is equal to or higher than the first fixed speed is determined to be satisfied, when the condition that the speed of depression of the brake pedal is equal to or higher than a fixed speed of depression is determined to be satisfied, or when the condition that the acceleration of the vehicle is equal to or higher than the first fixed acceleration which is a positive value, or is equal to or lower than the second fixed acceleration which is a negative value is determined to be satisfied.

According to the invention as set forth in claim 14, it is determined that the vehicle's emergency state is eliminated when one of the condition that the vehicle has stopped, the condition that the speed of the vehicle is equal to or lower then the second fixed speed, the condition that the deceleration of the vehicle is equal to or lower than the second fixed deceleration, and the condition that the time elapsed from moment when the operation of the motor is stopped is equal to or longer than the third preset time period is satisfied. Consequently, the operation of the locking means is automatically released at an earlier stage and more flexibly after the vehicle's emergency state is eliminated.

According to the invention as set forth in claim 15, after the vehicle's emergency state is eliminated and the operation of the rocking means is automatically released, the seat belt is restored automatically to the state as it was before the vehicle's emergency state was detected. Consequently, the passenger does not need to perform the additional lock releasing operation, and what is more, he or she can be released automatically from the restrained state.

CLAIMS:

1. A seat belt retractor comprising at least:

a reel for winding the seat belt,

a reel urging means for urging said reel in the seat belt winding direction,

locking means provided between a frame and said reel for allowing the rotation of the reel in the normal state and being actuated to prevent the rotation of the reel in the belt unwinding direction when necessary; and

a belt tension control mechanism for controlling the belt tension of said seat belt;

characterized in that said belt tension control mechanism comprises:

a motor for generating a rotational torque;

a power transmission path having the OFF-state in which a rotational torque is not transmitted between said motor and said reel and the ON-state in which a rotational torque is transmitted between said motor and said reel; and

a power transmission path switching mechanism for selectively switching said power transmission path between the ON-state and the OFF-state,

said power transmission path being actuated by a rotational torque of said motor.

2. A seat belt retractor as set forth in claim 1:

characterized in that said power transmission path includes a power transmission gear mechanism;

in that said power transmission path switching mechanism includes a switchgear axially movable for controlling the operation of said power transmission path switching mechanism;

in that the gear of said power transmission gear mechanism and said switchgear are both formed in helical gears and are engaged with respect to each other; and

in that when the gear of said power transmission gear mechanism is rotated by a rotational torque of said motor, said switchgear is rotated, and an axial tension generated in the axial direction by the rotation of said both gears moves said switchgear in the axial direction, thereby actuating said power transmission path switching mechanism and setting said power

transmission path into the ON-state.

3. A seat belt retractor as set forth in claim 2:

characterized in that said power transmission path further comprises a speed reducing mechanism for reducing the rotating speed of the motor transmitted from said power transmission gear mechanism and transmitting it to said reel;

in that said speed reducing mechanism comprises a sun gear, a ring-shaped internal gear rotatably mounted and having ratchet teeth on the outer periphery thereof and internal teeth on the inner periphery thereof, a planetary gear to be engaged with said sun gear and with said internal gear, a carrier for rotatably supporting said planetary gear and transmitting the rotation thereof to said reel, and a speed reducing gear provided so as to be rotated with said sun gear as a single piece for receiving the rotation of the motor transmitted from said power transmission teeth mechanism;

in that said power transmission path switching mechanism further comprises a stop lever being rotatable between the non-engaging position in which said stop lever is not engaged with said ratchet teeth and the engaging position in which said stop lever is engageable with said ratchet teeth, and a plunger for placing said stop lever to the non-engaging position in the normal state in which said switchgear does not move in the axial direction to allow the free rotation of said internal gear and for preventing the rotation of said internal gear, when actuated by the movement of said switchgear in the axial direction, by placing said stop lever to the engaging position so that said stop lever is engaged with said ratchet teeth; and

in that said power transmission path is constructed in such a manner that said power transmission path is set to the OFF-state when said internal gear is free to rotate, and is set to the ON-state when said internal gear is prevented from rotating.

4. A seat belt retractor as set forth in claim 1:

characterized in that said power transmission path comprises a power transmission gear mechanism, and said power transmission path switching mechanism comprises a control lever being rotatable for controlling the operation of said power transmission path switching mechanism; and

in that when the gear of said power transmission gear

mechanism is rotated by a rotational torque of said motor, said power transmission path switching mechanism is actuated by the rotation of said rotatable control lever so that said power transmission path is set to the ON-state.

5. A seat belt retractor as set forth in claim 4,

characterized in that said power transmission path comprises a speed reducing mechanism for reducing the speed of the rotation of the motor transmitted from the power transmission gear mechanism and transmitting it to said reel,

in that said speed reducing mechanism comprises a sun gear, a ring-shaped internal gear rotatably mounted and having ratchet teeth on the outer periphery and internal teeth on the inner periphery, a planetary gear to be engaged with said sun gear and said internal gear, a carrier for rotatably supporting said planetary gear and transmitting the rotation thereof to said reel, and a speed reducing gear provided so as to rotate with said sun gear as a single piece for receiving the rotation of the motor transmitted from said power transmitting gear mechanism,

in that said power transmission path switching mechanism further comprises a stop lever being rotatable between the non-engaging position in which said stop lever is not engaged with said ratchet teeth and the engaging position in which said stop lever is engageable with said ratchet teeth, so that, in normal state in which said control lever does not rotate, said stop lever is placed to the non-engaging position to allow the free rotation of said internal gear, and when said control lever is rotated, said stop lever is placed to the engaging position and engaged with said ratchet teeth to prevent the rotation of said internal gear, and

in that in the state in which said internal gear is free to rotate, said power transmission path is set to the OFF-state, and in the state in which the rotation of said internal gear is prevented, said power transmission path is set to the ON-state.

6. A seat belt retractor as set forth in claim 5, characterized in that said control lever comprises a lever spring having a prescribed resiliency.

7. A seat belt retractor as set forth in any one of claims 3, 5, and 6, characterized in that said planetary gear comprises a large planetary gear having a large diameter

to be engaged with the sun gear all the time, and a small planetary gear provided so as to rotate with said large planetary gear as a single piece, having a diameter smaller than that of said large planetary gear, and being engaged with the internal teeth of said internal gear all the time.

8. A seat belt retractor as set forth in any one of claims 3, 5, 6, and 7, characterized in that said braking mechanism is provided with a transmitted torque limiting mechanism that discontinues transmission of a power when the power transmission torque is equal to or higher than the prescribed value.

9. A seat belt retractor as set forth in claim 8, characterized in that said transmitted torque limiting mechanism is composed of a supporting portion of said planetary gear that is ruptured when a power transmission torque is equal to or higher than the prescribed value.

10. A seat belt retractor as set forth in any of claims 3, 5, 6, and 7, characterized in that said power transmission gear mechanism includes a belt power transmission mechanism comprising a first and a second pulleys and an endless belt looped between the first and the second pulleys, and in that the belt power transmission mechanism is provided with a transmitted torque limiting mechanism that discontinues power transmission by generating a slip between said endless belt and at least one of said first and second pulleys when a power transmission torque is equal to or higher than the prescribed value.

11. A seat belt retractor comprising at least a reel for winding a seat belt, locking means provided between said frame and said reel for allowing rotation of the reel in normal condition and being actuated to prevent the rotation of the reel in the belt unwinding direction when necessary, and a belt tension control mechanism for controlling the belt tension of said seat belt, characterized in that said belt tension control mechanism comprises a motor for generating a rotational torque, a power transmission path for transmitting a rotational torque between said motor and said reel, vehicle's emergency state detecting means for detecting the emergency state of the vehicle and sending a signal, and motor drive control means for driving said motor in the belt winding direction for the first

preset time period according to the signal from the vehicle's emergency state detecting means to restrain the passenger, then stopping the operation of said motor, and when the prescribed conditions are satisfied after said motor has stopped, driving said motor again in the belt winding direction additionally for the second preset time period.

12. A seat belt retractor as set forth in claim 11, characterized in that said vehicle's emergency state detecting means detects that the vehicle is in the emergency state when it determines that three conditions, that is, the condition that the speed of the vehicle is equal to or higher than the first fixed speed, the condition that the speed of depression of the brake pedal is equal to or higher than the fixed speed of depression, and the condition that the deceleration of the vehicle is equal to or higher than the first fixed deceleration are all satisfied.

13. A seat belt retractor as set forth in claim 11, characterized in that said vehicle's emergency state detecting means detects that the vehicle is in the emergency state when the condition that the speed of the vehicle is equal to or higher than the first fixed speed is determined to be satisfied, when the condition that the speed of depression of the brake pedal is equal to or higher than a fixed speed of depression is determined to be satisfied, or when the condition that the acceleration of the vehicle is equal to or higher than the first fixed acceleration which is a positive value, or is equal to or lower than the second fixed acceleration which is a negative value is determined to be satisfied.

14. A seat belt retractor as set forth in any one of claims 11 to 13, characterized in that said prescribed condition is one of the condition that the vehicle has stopped, the condition that the speed of the vehicle is equal to or lower then the second fixed speed, the condition that the deceleration of the vehicle is equal to or lower than the second fixed deceleration, and the condition that the time elapsed from moment when the operation of the motor is stopped is equal to or longer than the third preset time period.

15. A seat belt retractor as set forth in any one of claims 11 to 14, characterized in that said motor is driven in the belt unwinding direction for the third preset time

period after said motor is driven in the belt winding direction for said second preset time period.

16. A seat belt retractor substantially as shown in and/or described with reference to any of Figures 1 to 34 of the accompanying drawings.

Application No:	GB 0019106.4	**Examiner:**	Peter Macey
Claims searched:	1 - 10	**Date of search:**	15 November 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): B7B (BVRG, BVRP, BVRR)

Int Cl (Ed.7): B60R 22/34, 22/46

Other: Online: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	GB 2304540 A (TAKATA) whole document relevant	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		

Application No:	GB 0019106.4	**Examiner:**	Peter Macey
Claims searched:	11 - 16	**Date of search:**	16 February 2001

Patents Act 1977
Further Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): B7B (BVRG, BVRP, BVRR)

Int Cl (Ed.7): B60R 22/34, 22/46

Other: Online: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
	NONE	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		